ANNALS
OF THE
Association of American Geographers

VOLUME XVII JUNE, 1927 No. 2

THE GEOGRAPHICAL ACTIVITIES OF THE CASA DE LA CONTRATACION*

BY EDWARD L. STEVENSON

THE ORGANIZATION OF THE CASA

When, in the year 1492, Columbus set sail from the Port of Palos, it was on a private mission to discover "Islands and Mainlands," with Royalty as a patron, and not to find, by way of the West, a sea route to the Indies of the East. The rights and privileges of the discoverer, as well as his rewards, should success attend his efforts, were distinctly set down in the *Capitulación,* and the returns to the Patron were as clearly and as concisely stated therein.

After report had been rendered concerning the outcome of the great enterprise—that hitherto unknown lands had been discovered and claimed for the Spanish sovereigns—the question having to do with the administration of affairs touching the new discoveries received immediate consideration.

The recent union of Castile and Aragon, with the consequent bracing of absolutism, made it a comparatively easy matter for the Sovereigns to select a private body of administrators, if they chose so to do, to assist in the organization and control of the new interests. Seeing that hitherto there had never been a situation quite comparable to this which had now arisen, and that none of the existing functionaries of government had ever been called upon to give consideration to problems touching the organization of newly acquired trans-oceanic possessions, save for those first acquired Spanish outposts in the Atlantic, the Canaries, the way had now been opened for a new feature in the royal administration of Spain, unhampered by tradition or restricted by practice.

Before Columbus had started on his second voyage of discovery there

*Read before the Association of American Geographers at the Philadelphia meeting, December 29-31, 1926.

was prepared, what might be called, the outline of a colonial policy having to do with the western discoveries, and the organization of an agency to which it was proposed to entrust the handling of problems relating thereto. This, in the course of the years, came to be known as the Council of the Indies, over which Council for a considerable time Juan Rodregues de Fonséca, dean, bishop, and patriarch in succession, presided, being quite the controlling factor. In character this was but a personal Council of the Sovereigns, during its first years, though time saw its importance greatly enhanced. Its activities came to embrace administrative, legislative, and judicial functions, having its authority, now checked, now expanded as its personnel, or as the Sovereign might arbitrarily determine.

With the development of New World interests it soon became apparent that a better management of these interests could be effected by a separation of those which seemed primarily to be political from those which primarily were economic.

Almost, if not quite, contemporary in origin with this personal Council was a less definitely formed organization, approved by the sovereigns, which gave special attention to questions of trade and commerce, and what thereto directly pertained. With great rapidity this organization developed as trade interests expanded, and shortly before the turn of the century, that is after 1500, we find that by royal decree it received a name, the Casa de la Contratación, with assigned duties of a special character to perform, and with offices in the Admiral's apartment in the old Alcazár of Seville.

The efforts of the king and his advisors to establish an orderly method in dealing with the affairs of the new possessions were not at the outset in the highest conceivable degree successful. Clandestine voyages, for example, were numerous in the years immediately following the new discoveries. The reports of these expeditions, touching the coasts visited and more or less carefully charted, were soon known to any and all interested, and the uses they made of their knowledge became somewhat a source of disturbance to the authorities, in large part because they were beyond rigid systematic control.

The purpose of this paper is not to give an outline of the several activities of the Casa, but rather to direct attention very briefly to what was considered to be its geographical functions, its geographical activities in the broadest sense, stressing in particular the cartographical. To one of the early attempts at the supervision of ocean navigation it may first be noted, that we find a reference in a çedula dated March 18, 1500, approving an earlier ordinance for the regulation of a school of Basque pilots at the port of Cadiz, which school originated, says

the çedula, at a time so long since that "the memory of man runneth not to the contrary," while further therein is given some prominence to the question of laws for the regulation of voyages westward, and for the keeping of records relating thereto. In particular it may be noted that it was from this old school of pilots that some of the most noted chart-makers of Spain came, lending their influence to subsequent geographical activities of the Casa.

By a decree of January 20, 1503, provision was made for a very definite organization of the *Casa de la Contratación de las Indias,* later more generally known under the abbreviated name the *Casa de Contratación,* the *Casa,* or the *Indian House.* It was an organization which did not owe its origin, as I have previously intimated, to the Council of the Indies, although that Council exercised a sort of appellate jurisdiction over certain matter which came before the Casa in first instance.

The Work of the Casa

All maritime affairs, in the broadest sense of the term, fell to its jurisdiction in the passing years, including the direct regulation of overseas trade and commercial relations, the examination of pilots and masters and the granting of license to them, the charting of all the new regions from the detailed geographical records which it was demanded should be most carefully made and fully reported by those who had visited them, the formulation and the supervision of laws of navigation with an especial reference to the navigation of the western seas. Of the importance of this Indian House, before the close of the sixteenth century, Linajes writes, that "its jurisdiction is as large as its territory is boundless; its authority is so extraordinary that it has supplied the place of a Council, and has acted as such not only in reference to revenues and military affairs, with orders passing directly from the King to it; its wealth is such that none in Europe can compare with it; its credit so high that no private person could equal it; its pre-eminence is such that it had the appointment of all officers including admirals of the Royal fleet, and the civil magistrates; it gave passes to ships sailing to all ports, and the dispatching of advice boats with only its own owners."

Founding of a Cosmographical Department.—By decree of August 8, 1508, a geographical or cosmographical department of the Casa was definitely created. This was a department which we may call the Hydrographic Office, one of the first, if not the first, of such governmental offices created. This decree is one of much interest because of its detailed instructions. There is particular reference to the necessity for a better regulation of the drafting of maps of the new regional

claims. It is specifically stated therein, as to pilots, that the need is felt for more expert and better instructed men, who should not be ignorant of the quadrant, of the astrolabe, of navigators charts, of other instruments of navigation such as are needful to enable them to direct and govern the ships that navigate the seas to the new islands and mainlands. Therein Amerigo Vespucci is named Chief Pilot or Pilot Major, and only those whom he examined and approved by letter could be employed by the masters of the merchant ships. As information had been received of the use of many charts by different masters, charts differing, the one from the other in the record of the geographical location of lands and islands in the Indies, it was further ordained that a general or model map should be made to be called a Padron Real or Pattern Map, and to that end the several officials of the Casa were directed to call together all pilots of marked ability to assist in its construction. Pilots were not to be permitted to make use of any other map than this, and they were directed, upon finding new islands or lands, new ports or bays, or any other thing—currents or tides, headland or mountains—which might serve the purpose of subsequent identification of localities, to enter the same in the copy of the Padron Real which they carried, reporting all such entries made on return to Seville, but nothing should be inserted that was not properly attested and sworn to. This decree seems to mark the real beginning of an interesting development in Spain's orderly handling of her New World affairs.

Twice each month, by special order, the Pilot Major was to meet with the other pilots, and with the chart makers or cosmographers, to consider with them the question of inserting the new information in the Padron, an order later changed to read once each month or oftener, if thought neecssary, the verification being entrusted to the President, the Judges of the Casa, the Pilot Major, and the cosmographers.

Amerigo Vespucci, Chief Pilot.—Not long after the issue of the decree of 1508 provision was made for the appointment of three chief pilots, instead of the one pilot major which office Amerigo Vespucci was the first to fill—that is there was to be a resident pilot of the Indian House, a pilot of the royal armada to secure the trade of the Indies, and in addition there was to be a pilot of the new Spanish fleet. It was the chief pilot of the Indian House, who in addition to his other duties passed upon the qualifications of the professors or teachers of cosmography, that is of geography, and who supervised the manufacture of all instruments of navigation. He was to direct the preparation or the revision of the Pattern Map, but was forbidden to teach navigation himself, or the use of the instruments, and whoever

studied under him could not be examined for a period of two years thereafter, "which was done," says Linajes, "that affection for his own scholars might not cause him to wink at their ignorance." Nor was he permitted, though it seems with exceptions, to make charts or instruments to sell; seeing that it was his business to judge the character of those used in a voyage to the Indies "he might therefore never see any fault in his own."

Beginnings of Spanish Cartography.—It may first be noted especially that but few charts were drafted before an official supervision was undertaken by the Casa, indeed but few of the first quarter of the sixteenth century are now known, yet from the few extant we are able to obtain a fair idea of the nature of the confusion to which allusion was made.

Spanish cartography of the New World, as we now know it, may be said to begin with the chart of the year 1500 by the Biscan Juan de la Cosa. He was of that school of Biscan pilots and cosmographers located, as before noted, at Cadiz. There is no reason for thinking that his chart has in it anything of a particularly official character or that it had undergone official supervision, yet it contains a record of discoveries to date made by those who sailed under official orders. Marking, as it does, the real beginning of New World cartography, and because of the great reputation of its author, there is justification for calling it a sort of Pattern Map, one more or less closely followed before the order definitely was given for an official *Padron*. It may well have served as a basis on which to build the new *Padron* which Vespucci was ordered to prepare in the year 1508. Other maps of, say, that first decade of the sixteenth century, strikingly differ in outline from it, with perhaps a noted exception in the Pesaro Map of about 1508 which the author of this paper expects soon to publish. This exhibits certain striking features suggesting a Vespuccian origin; indeed it may almost be counted a fairly good copy of Vespucci's 1508 Padron. The Cantino and the Canerio maps of that early period may be noted in passing, although they show the marks of a pronounced Portuguese origin or influence, yet, on them are indicated Spanish discoveries in the New World.

There must have been many maps drawn in that period of great exploring activities which now are lost, both direct and indirect reference to which we find in the written records, and many which doubtless would prove to be of greater scientific value than those which have escaped concealment or destruction.

Map Making Under de Solis.—Amerigo Vespucci died in the year 1512, and was followed in the office of Pilot Major, that is of chief

cosmographer or geographer, by Juan Diaz de Solis, a man skilled both in the theory and the practice of navigation.

It appears that the supervision of the Padron Real, and of the geographical information which came flowing into the Casa, was entrusted jointly to him and to Juan Vespucci, nephew of Amerigo, to whom was given the title Pilot of His Majesty. They were authorized to dispose of copies of the existing *Padron* begun in the year 1508, and they alone, at a price fixed by the Casa. It was soon found however that inferior duplicates could easily be obtained, and of this fact the Pilot Major entered complaint in the year 1513. In this complaint it was particularly noted that the chartmakers were employing different measures for a degree, and as a consequence great confusion resulted.

While the official *Padron* and its counterfeits were becoming more unsatisfactory in character, it appears that there had come into prominence certain independent but reputable chartmakers who were winning favor for the character of their work, notably one Andreas de Morales. Peter Martyr refers to an excellent copy of his work he had seen in the office of Bishop Fonséca, and the historian Herrera tells us that Solis himself praised Morales' maps as possessing superior excellence; this the King also did in a decree of the year 1515. The discovery of a Morales map of this period is a desideratum of first importance with students of early Spanish discovery and exploration in the New World.

That the Casa might continue, with at least the semblance of official supervision, it was ordered, in the year 1514, that a new Pattern Map should be constructed, which, as the decree states "should be true and trustworthy," that Juan Vespucci should be associated with Juan de Solis, the Pilot Major, in its preparation, and that after its completion it should hang in the Indian House, where all navigators might carefully inspect it. It was further ordered that none but Juan Vespucci should be privileged to make copies of it for sale. This order assumes new significance in the light of the fact that a large World Chart, the second one known of this same Juan Vespucci, or Vespuchi as he wrote his name, but the only one of his in manuscript signed and dated, has recently become one of the choicest treasures of a great American library.

Conference of Junta de Pilotos.—From Herrera, and from Herrera alone, we get the information, but very incomplete, that in the year 1515 a "Junta de Pilotos," or a Commission of Pilots, assembled in Seville, presumably in the Hydrographic Office of the Casa, for the purpose of considering certain chart records, a conflict having arisen

between Spain and Portugal over their respective claims in the Brazilian region. Among the members of this Junta we note the name of Sebastian Cabot, who three years previously had come to Spain from England, the names of the Pinzons, and of Antonio Maurio an Italian pilot of the King.

The question at issue centered in the claims to which the Treaty of Tordesillas of 1494 had given rise, and the disagreements in the map records of the day doubtless owed, in part, their disagreement to a real purpose on the part of both Spain and Portugal to falsify. Santa Cruz expressly states that the Portuguese were in the habit of making incorrect maps for foreigners but correct ones for themselves; and we may be certain there were Spanish chartmakers equally guilty. It is disappointing that we do not have a detailed report of this commission's deliberations. There is no positive assurance that it proposed the construction of a new map, much as the need of such an instrument was felt.

Maps of Coastal Areas.—During these years, map sketches of the new coasts which came into the Casa, must have multiplied rapidly, in which maps there were records of the expeditions of Ponce de Leon, of Balboa, of Pinzon and Solis, of Cordoba, of Grijalva, of Alaminos, of Cortes, of Ayllon and of Magellan. We have however but scant geographical record for a careful checking of their reports. Very few if any, of their local coast sketches have come down to us out of the Hydrographic Office, but we do have from this time onward a considerable number of remarkably well drafted Spanish maps, with maps drafted in other countries of Europe, based very largely on Spanish sources.

Some Famous Cartographers.—We know of the enlarging activities of the Hydrographic Office with the passing years, of the creation of the title of Cosmographer Major, of the appointment of teachers of cosmography and of the practice of navigation, of the enlarging group of distinguished chartmakers in Seville, practically all of whom connected themselves in some manner with the geographical department of the Casa, at least we seem to find them available for official service at any and all times. Hither came Diego Ribero, Francisco and Rodrigo Faleiro, the Reinels, father and son, from Portugal; Juan Vespucci and Antonio Maurio from Italy; and of native Spanish geographers and chartmakers there may here be named Garcia de Torreno, Andreas de Morales. with distinguished successors in Alonso Santa Cruz and Alonso Chaves.

The Badajos Junta.—The return of Sebastian del Cano, a survivor of the Magellan expedition, brought Spain and Portugal again

into lively controversy over geographical records and territorial claims, into which the cosmographers and pilots of the Casa were immediately drawn. In a crisis, such as was here created, the question of greatest importance centered in the maps. Portugal alone had charted the Moluccas, in so far as they may be said to have been charted, but both Spain and Portugal had charted the Brazilian coasts through which passed the Line of Demarcation, the line with yet undetermined definite position, from which it was necessary to reckon distance in longitude in the determination of a Molucca claim.

Spanish plenopotentiaries were appointed January 25, 1524, to meet with representatives from Portugal for the purpose of entering into a full and definite discussion of the respective claims to the Moluccas, whether they lay within the Spanish or the Portuguese hemisphere.

Naturally the question of territorial claims was one to which recent events especially gave rise, and which could not have been settled by the Treaty of Tordesillas of 1494, nor by the Junta of the two powers which met in the year 1515. This conference of 1524 came to be known as the *Badajos Junta*. Its deliberations need not here claim detailed consideration, and while the discussions ranged chiefly in the field of geography, only the relation of the questions which came before the cosmographers of the Casa, and particularly to the Casa's subsequent procedure in the matter of charting the new discoveries, come within the limits of the present survey.

Among the Spanish members of the Junta one notes a distinguished company of cosmographers, astronomers, and pilots, all holding positions among the officers of the Casa—the Pilot Major Sebastian Cabot, Ferdinand Columbus, Sebastian del Cano, Juan Vespucci, Estevam Gomez, Diego Ribero, Nuno Garcia de Torreno, and others of somewhat lesser note.

There must have been charts of the day marking the Line of Demarcation as variously interpreted, and those must have been laid before the Junta; we indeed are told as much, yet none of these charts are extant except the Cantino, as before noted, and the Canerio, both of Portuguese origin, and the Munich-Portuguese chart of about the year 1519, and we do not know that they were in evidence.

A telling argument presented by the Spaniards in support of their claims rested upon a Portuguese chart which had fallen into their hands, and which, we are told, laid down the island of San Antonio of the Cape Verde group 22° east of the Portuguese Prime Meridian; the Cape of Good Hope in longitude 79° 50′; Cape Cormorin in longi-

tude 156°; Malacca in 180°, and the Moluccas 206°, or 26 degrees east of the line of Demarcation in the far east as interpreted by the Spanish, hence the conclusion that they clearly were within the hemisphere of Spanish claims. It may be noted that the compromise of the year 1529, as stated in the Treaty of Saragossa of that year, Spain gave over to Portugal her claim to the Moluccas and to all islands and lands up to the meridian 17 degrees to the eastward thereof, neither party apparently realizing that an extension of the line, counting this meridian as coincident with the Line of Demarcation, on around the world, would pass to eastward of Brazil and leave all territory in the New World to Spain.

It is interesting to note how uncertain was such a cosmographer and cartographer as was Diego Ribero, perhaps the most distinguished of all in the Spanish service at that time, when he came to lay down the Molucca Islands on his charts, as he duplicated there his coastlines, these representations being separated by about fifteen degrees of longitude. It might, however, be admitted that he merely thought to represent the position of Spanish and of Portuguese claims before and after the Treaty of Saragossa, and not that he shrank from the logic of his own scientific theories.

A Revision of Pattern Map.—Herrera tells us that in the year 1526 King Charles I (Emperor Charles V), observing that the existing sea charts differed greatly the one from the other in representation of the islands and lands of the Indies of the West, in both latitude and longitude, and in the marking of the ship's courses to the same, again thought it well that means should be taken to have corrections made. Command was therefore given to Ferdinand Columbus to call all cosmographers and pilots, whom he thought worthy, to a conference, and that he should confer with them concerning a map revision and the making of a new Pattern Map, this being the third ordered within twenty years, which should be kept in the Indian House at Seville, and according to this Royal Pilots, in future, should order and direct their course. It seems to be nowhere stated that this Padron was actually completed, but we have some very interesting information concerning one which was drawn about ten years later. Although that too has disappeared, I venture to entertain a very lively hope, the result of a recent research visit to Spain, with much mousing about in out of the way places, wherein such things have a fashion of hiding themselves away, I say entertain the hope, that it may be found.

The Work of Juan Vespucci.—Sebastian Cabot, one of the cosmographers chosen to assist Columbus in his newly appointed task, sailed

away in the year 1526 on his so-called Molucca expedition, but which turned out to be only a La Plata expedition, lasting for a period of four years. During his absence his duties as Pilot Major of the Casa were performed by Juan Vespucci and Nono Garcia de Torreno, the former disappearing entirely from the Casa's records in the following year. For some unexplained reason Vespucci seems temporarily to have been deprived of his office in the year 1525. It could, however, have been but temporarily, since we find him enjoying royal favor the following year, then disappearing altogether, as noted, from the records.

But recently we have come into possession of very definite information as to the manner in which he employed, perhaps a very considerable part of his time during the year 1526, this being in a study of the geographical records of the Casa with an effort at their interpretation, adding the while to his fame not only as Pilot of the Indian House, and as expert cosmographer, but also as chart maker. It has been noted that with Juan de Solis he had been entrusted, in the year 1514 with the task of correcting the Padron Real, that his uncle Amerigo had been ordered to construct in the year 1508, and some months later had received a command to assist in the construction of a new one, with the sole privilege for the sale of this map.

New information concerning him comes to us through his great chart, the most important of all those of that early period to be found in any American library, the second known dated Spanish map of the New World, counting the Juan de la Cosa of 1500 as the first. Time does not permit a detailed reference to this very remarkable document. This holograph of Juan Vespucci himself, is about nine feet by three feet in size, drawn on vellum of excellent quality, the whole being still in an excellent state of preservation. Near a very conspicuous representation of the Royal Arms of Spain, we find the legend "Jñ Vespuchi piloto de sus ma^{ta} me fezit en sevilla ño d. 1526." ("Juan Vespuchi pilot of His Majesty made this in Seville in the year 1526.") We can hardly claim that it is a copy of the Padron Real though made by one who had experience in just that line of activity. It has been my pleasure to make a very detailed study of this map the results of which I had hoped, and still hope soon to publish. Just a further word of detail relative to this Vespucci chart may here be of interest. It is of the Portolan Chart type, that is, a chart primarily intended for navigators. Though not including detailed entries of discoveries to date, it seems to have omitted nothing of great importance, leaving it easily possible for additions or corrections authorized by the Pilot Major and the Royal Cosmographers such as they would draw from the Casa's chest of records. It marks for the first time on a known

dated map the Strait of Magellan, but calls it "The Strait of San Antonio discovered by Ferdinand Magellan by command of His Majesty." It is the first known dated map to note the discovery of Lucas Vasquez de Ayllon, calling the region he visited "Terra neuva de Ayllon." It omits the coast visited by Estevam Gomez late in the year 1525, whose report and charts definitely served to connect the coast region visited by Ayllon with the Baccalaos country. Certain Spanish geographers, some years before, had professed to believe in a continuous coast line from Baccalaos southward to Brazil, and for the North Atlantic coast region the information thought to have been possessed by Sebastian Cabot may have been the basis for such belief, if the basis were not the information brought back by some clandestine voyager. There is no written record now known describing a Spanish expedition which followed our own Atlantic coast before the time of Ayllon and Gomez, but the charts of the first quarter of the sixteenth century give us some interesting information.

Work of Ferdinand Columbus.—Herrera states, refering to the order given to Ferdinand Columbus in the year 1526, that "he applied himself to his task with great zeal, so that many errors in the maps were corrected, which were of great value." There is no chart known which bears his signature, but there are four or five important Spanish charts known which were made within a decade of that date, not all signed, but all clearly the work of the Casa's geographers. They are not in exact agreement in outline, in geographical nomenclature nor in general or special geographical information, and yet they are so strikingly similar that elsewhere I have referred to them as charts of the Casa de la Contratación of the Diego Ribero type. They doubtless represent closely the Pattern Map but each has its individual modifications. Neither of them bears the official attest, although each gives evidence, of a very pronounced character, of having been based upon information furnished by the geographical department of the Casa.

Descriptive Aspect of the Maps.—Aside from their historical and their general geographical records—their references to the fauna and the flora, not accurate as our knowledge of today tells us, but interesting and important because they have laid down here the record of impression—they record the beginnings of a scientific geographical knowledge of the New World. They tell us much of the nautical astronomy of the day, concerning the courses sailed by the navigators, the character and the uses of certain instruments of navigation. Some of them give only the coastlines, the harbors, the rivers, to that point reached by the Spaniards and Portuguese to date. They clearly remind of the difficulties in determining the latitude and the longitude of places,

and raise, among other interesting questions that one, as to what extent the variation of the magnetic needle was taken into consideration, if at all, in recording coast observations, an interesting problem in a study of the real and the imaginary geographical conditions as determining factors in early discovery and exploration, a topic somewhat fully treated in the author's forthcoming studies.

Expansion of the Influence of the Casa.—To this point my presentation has touched little more than the first quarter of the sixteenth century in the geographical activities of the Casa de la Contratación. Its activities continued unabated, now enlarged, now restricted for two and more centuries; the influence of its activities spreading into all lands wherein there developed an interest in the New World.

In concluding the paper as presented at the Philadelphia meeting of the Association, there was a brief screen presentation of early Spanish geographical conceptions of the New World, including first a reference to those maps which may be said to stand as basal. Very briefly there was traced the development of what may be called the official cartography as left to us in some of the best extant maps of the first two or three decades after the Columbus discovery. The results of the leadership of such geographers as Alonso Santa Cruz and Alonso Chaves were noted, as were certain special typical survivals of the Casa's cartographical activities, concluding with a notice of the spread of Spanish cartographical influences into other lands during the first half of the sixteenth century, and a reference to recent finds in Spain, in Italy, in France, in England.

The few illustrations presented herewith, being reproductions direct from the originals, are much reduced in size. They will serve however to give point to the preceding discussion, having been selected to show in general the character of what we may call the official cartography of early Spanish discoveries in the New World according to records which came into the cosmographic, geographic, or hydrographic department of the Casa de la Contratación. (See pp. 53-59.)

Descriptions of the Reproductions

Fig. 1. The Juan de la Cosa map dated 1500. It tells quite a remarkable story for a date so early. The Atlantic coast line of the New World is laid down, not with an accurate trend, but with an approach thereto, seeming to tell of discoveries concerning which we find no word in the written record. The location of the Cabot discoveries is indicated, and Cuba is represented as an island. This map, as has been noted above, perhaps should not be counted as one having the official stamp, yet it may have served as a semi-pattern map prior to that constructed under direct order from the Casa.

Fig. 2. The Pesaro map of ca. 1508. So nearly does this map seem to accord in its details with the records left us by Amerigo Vespucci in his accounts of his discoveries along the New World coasts, that it has been considered to bear a very close resemblance to the Padron Real or Pattern Map which he was ordered to construct in the year 1508.

Fig. 3. The Turin-Spanish map of ca. 1522. We do not know the author of this map. By reason of the richness of its nomenclature, the richest of the century, so far as we have knowledge, and by reason of the fact that it employs both Spanish and Portuguese nomenclature, there is reason for thinking it bears a close resemblance to that probably issued shortly after the Junta meeting of 1514. It is at least an interesting early map, omitting almost the entire Atlantic coast of North America, marking the greater part of the coast region of the Gulf of Mexico, and for the first time represents Florida as an island.

Fig. 4. The Juan Vespuchi map of 1526. It has been noted above that great importance attaches to this map by reason of the fact that its author had direct supervision, for a decade and more, of the official cartography of the Casa. It perhaps would be claiming too much to assert that we have here a copy of an official pattern map.

Fig. 5. The Weimar-Spanish map of 1527. This is a map clearly based upon data furnished by the Casa, and was drawn by "a cosmographer of his majesty" says a legend appearing across the top. It is a map which I have chosen to call one of the Ribero type, there being several known, which, in its outlines, it closely resembles, some of which are signed as the work of Diego Ribero.

Fig. 6. It is greatly to be regretted that we do not have a copy of the Padron Real constructed under the supervision of Alonso Chaves. Only second in importance to this map itself reported to have been completed in 1536 we have Chaves' detailed account of his map in manuscript which the author of this paper has in readiness for early publication. Though we do not have the Chaves map we do have some interesting coast sketches, of about this date, drawn by Alonso Santa Cruz, such as must have been based upon the sectional coast records brought back to the Casa by early explorers. Santa Cruz was himself a cosmographer of his majesty, and while he himself was not directed to draft a Pattern Map, he was in a position to do so. The sketch here given represents the Atlantic coast line as it would appear from the sectional sketches joined together, which I have undertaken to do for the first time. The small sketches, from which the completed sketch has been made, are represented in the cut.

Fig. 7. Map of Lopo Homem, a Portuguese, of 1554. While this map is clearly of Portuguese origin, it is interesting to note that it makes very complete record of Spanish discoveries to date. It is here included by reason of the fact that it may well be considered as a near approach to the *Padron Real* of Alonso Chaves of 1536, since the names along the Atlantic coast, in particular, accord with the names as given in the Chaves manuscript record. This is a little known map and is one which the author has been planning to publish in the near future.

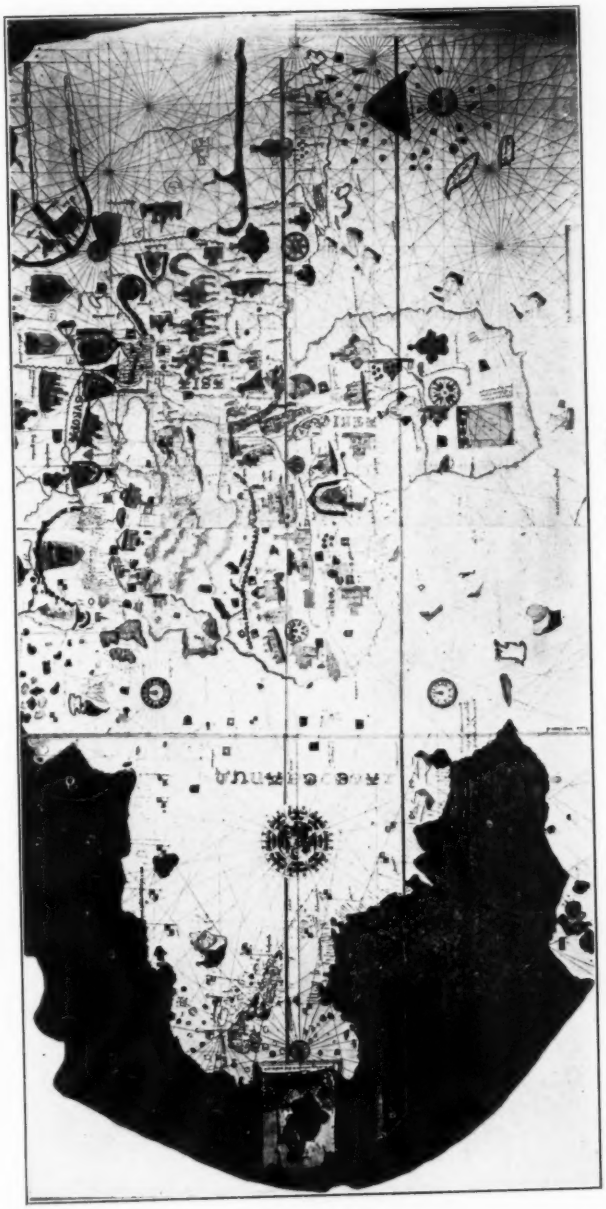

FIG. 1. Juan de la Cosa Map, 1500

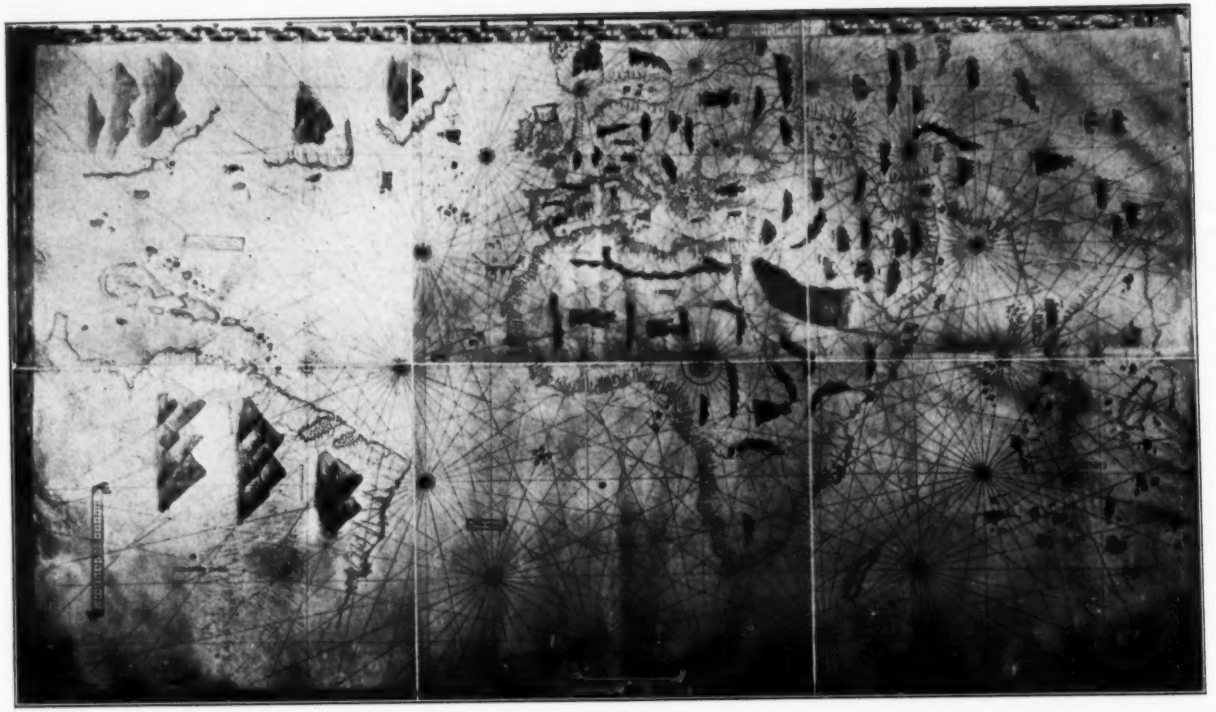

FIG. 2. Pesaro Map. Ca. 1508

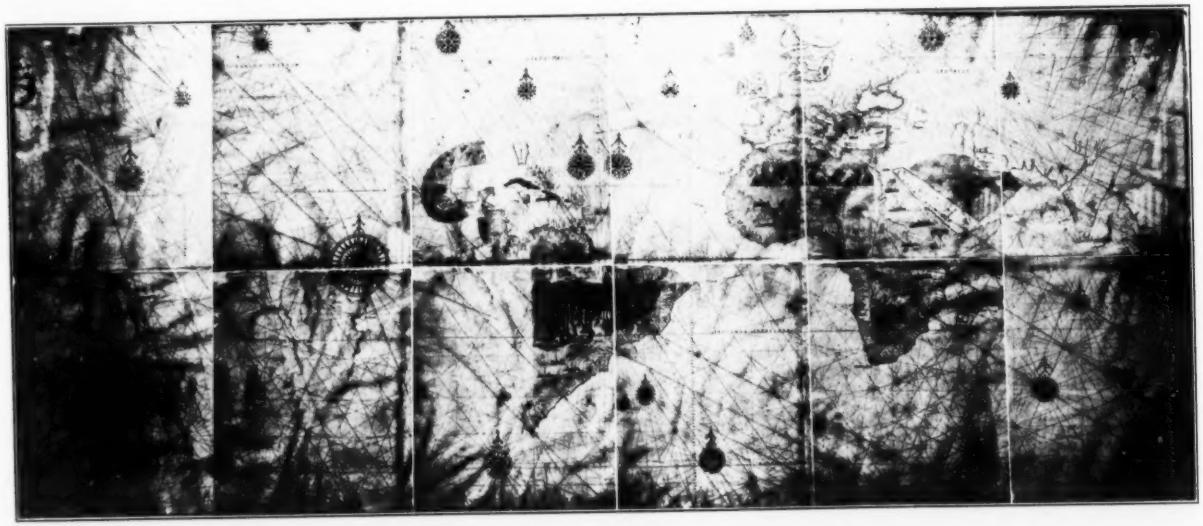

FIG. 3. Turin-Spanish Map. Ca. 1522

FIG. 4. Middle Section of Juan Vespuchi Map, 1526

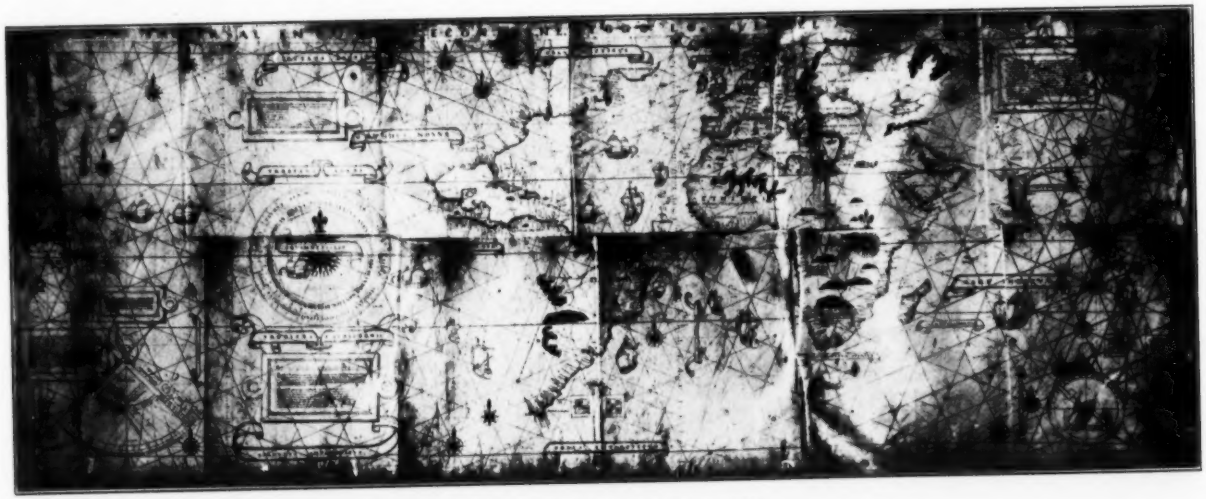

FIG. 5. Weimar-Spanish Map, 1527

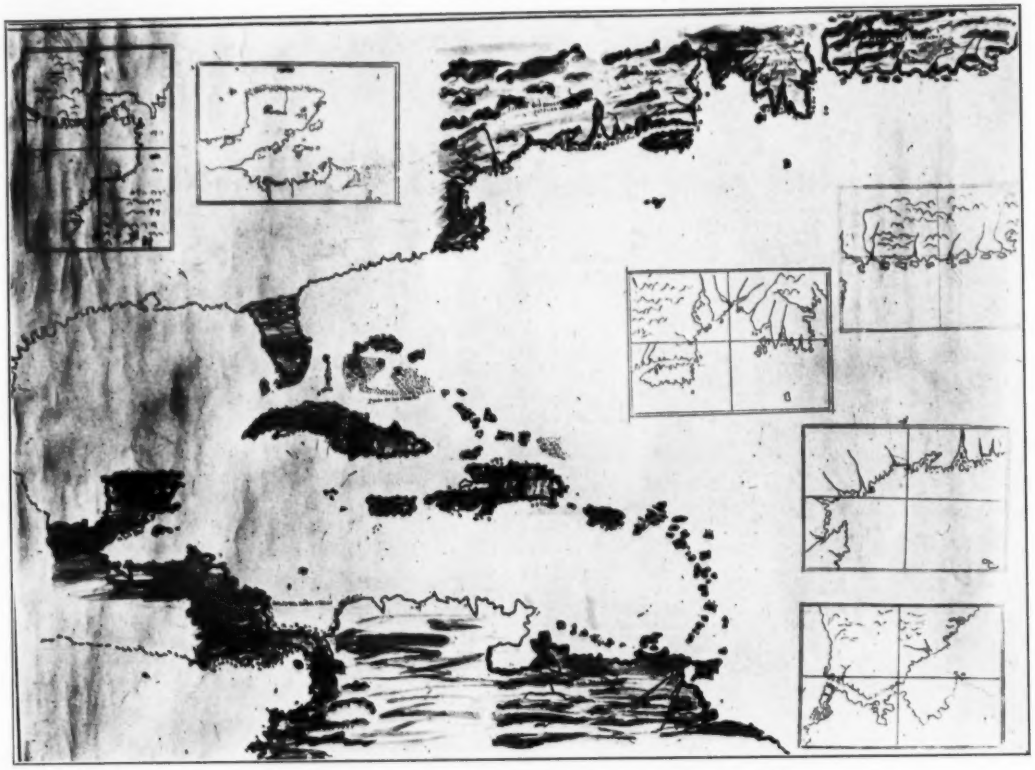

FIG. 6. Reconstructed Alonso de Santa Cruz Map. Ca. 1540

Fig. 7. Lopo Homem Map, 1554

THE BRÜCKNER CYCLE OF CLIMATIC OSCILLATIONS IN THE UNITED STATES*

ALFRED J. HENRY

In 1890 Dr. E. Brückner, professor of geography in the University of Berne, announced the discovery of a climatic cycle of an average length of thirty-five years. The quantity of evidence submitted was overwhelming and the reality of the cycle has not been seriously questioned. Some modern writers, however, have attributed to the cycle much more stability than it really possesses, or than was ever claimed for it by its discoverer.

Brückner's work was published in Pencks' Geographische Abhandlungen, Band IV-Heft 1, in 1889, and in a separate volume in the succeeding year.

One who has examined the original presentation must be impressed by the very great mass of material assembled and discussed. But whether it is humanly possible for any single individual, however well equipped he may be, to critically examine, interpret, and appraise the meteorological records from all parts of the earth is another matter.

The great bulk of Brückner's material is drawn from European sources and is presented in the following order:

(1) Secular variation of the Caspian Sea.
(2) do of lakes and seas without outlet.
(3) do of river heights.
(4) do of precipitation.
(5) do of atmospheric pressure.
(6) do of temperature.
(7) do of times of grape harvest in Europe, the occurrence of severe winters, the advance and retreat of glaciers, etc., all or the greater part of which is found in European records.

The Brückner Cycle Defined

Average length: This is said to be thirty-five years, although Clough[2] assigns a mean value of thirty-six years. Each cycle is composed of a cool-humid half and a warm-dry half; the yearly temperature and precipitation, for example increases to a maximum and then decreases to a minimum, to be sure in an irregular manner, but in such way as to be recognized in five-year means. The time between two maxima or two minima may vary between twenty and fifty years.

* Presented before the joint meeting of the Association of American Geographers and the American Meteorological Society at Philadelphia, Pa. Dec. 30, 1923.

Amplitude: The amplitude of the temperature oscillations counting from the highest to the lowest point reached in the five-year means is small, not exceeding one degree Centigrade, and in the term of years 1836-71 it was only half a degree C. The variation in precipitation for five-year groups of means for the years 1731-1881 was from 9 per cent above the normal to 8 per cent below. Much greater local variations both of temperature and precipitation occur in various parts of the world; but in the grouping of a large number of stations in a single mean the tendency is to reduce the extreme values which are found for individual stations.

Brückner's results, in so far as they are derived from systematic meteorological observations, are based essentially upon the records available for the fifty-six years between 1830 and 1885 inclusive.

The number of useful temperature and precipitation records prior to those years was inconsequential.

Brückner found in his studies of climatic oscillations certain large regions which he has called "regions of regular oscillations;" in other regions he found a distribution the reverse of that just mentioned and these were classed as "regions of permanent exception;" and in still other regions he found a distribution that for a time followed his "regular" distribution and then suddenly reverted to something different. These he classed as "regions of temporary exception." In his later writings, however, he claims that the oscillations are world wide.[3]

The Brückner Cycle Tested

In any attempt to discover the Brückner Cycle in meteorological records, two courses are open, first by means of long series of observations at single stations considered both singly and collectively, second by means of short records that may be combined in a single mean that will truly represent the general mean for the area in which the stations are located.

I have analyzed the Stockholm, Sweden, record as representative of northwest Europe, and present the results below:

Temperatures.—Analysis of Stockholm records of temperature.[4]

Length of record.....150 years, 1756-1905..
Standard Deviation of annual means.....0.91° C (1.6° F).
Greatest number of consecutive years with positive deviation of one degree (C) or more.....2 (1797-98), average for the two years, 1.36°C (2.5°F).
Greatest number of consecutive years with negative deviation of one degree (C) or more.....3 (1784-86), average for the three years, 1.3C (2.3F).
Greatest number of consecutive years with positive deviation of 0.5° to 2.0°C..... 43; Av'g. interval 3.5 years.
Greatest number of consecutive years with negative deviations of 0.5° to 2°C..... 32; Av'g. interval 3.2 years.

The single group of three consecutive years having the greatest positive deviation was 1822-24 with an average of 1.74°C (3.1-F).

The single group of three consecutive years having the greatest negative deviation was 1784-86 with an average of 1.3°C (2.3°F).

In the 150 years of observation at Stockholm there were nine groups of three or more consecutive years with a positive deviation of 0.50° C. or more (0.9° F.) and ten groups of three or more consecutive years with negative deviation of the same amount. The results are given in the table below:

Warm years		Cold years	
1789–91	avg. deviation 1.24C.	1770–72	avg. deviation 0.64C
1796–98	avg. deviation 1.13	1784–88	avg. deviation 1.02
1817–19	avg. deviation 0.90	1803–10	avg. deviation 0.61
1821–27	avg. deviation 1.21	1828–30	avg. deviation 1.01
1857–59	avg. deviation 0.77	1835–42	avg. deviation 0.53
1872–74	avg. deviation 0.78	1844–47	avg. deviation 0.63
1882–84	avg. deviation 0.55	1860–62	avg. deviation 0.70
1889–91	avg. deviation 0.50	1864–67	avg. deviation 1.05
1894–96	avg. deviation 0.87	1869–71	avg. deviation 0.89
		1875–77	avg. deviation 1.03

One of the outstanding features of the data in the above tabulation is the obvious fact that the cold years are not separated from the warm by ten to fifteen years as required by the Brückner Cycle, but rather that they follow each other almost immediately, thus the warm years 1821-27 were followed immediately by the cold group of 1828-32, then followed two warm years and these were immediately followed by eight consecutive cold years with the peak of the cold in 1838, just two years after the peak occurred in the United States.

Then followed five groups of cold years in the next thirty-five years instead of a single one; the most intense of these was the one of 1864-67.

Turning now to the records of a large geographic area, I have used the statistics of mean annual temperature for the United States computed and published by me in the *Monthly Weather Review* of 1923.[4]

Comparing the data so assembled with those of Brückner it is seen that the temperature records from about 1830 onwards, in some but not in all cases, agree fairly well with the Brückner epochs of maximum and minimum temperature.

This important exception, however, is to be noted, viz, that in the nineteenth century there were eighteen occasions when a grouping consisting of two or more years occurred, any one of which reasonably might be considered as fulfilling the expectations of the Brückner Cycle

of warm and cold, wet and dry epochs. The group of warm years occurred with an average interval of 10 years, and the cold with an average of 9.2 years.

TABLE 1. Groups of Consecutive Warm Years and Cold Years in Nineteenth Century in U. S.

Groups of warm years	Interval (years)	Groups of cold years	Interval (years)
1801–03	6	1807–09	11
1825–28	22	**1815–18**	6
1830–34	2	1835–37	17
1845–46	11	1843–44	6
1853–54	7	**1856–57**	12
1863–65	9	1872–73	15
1870–71	5	1875–76	2
1877–78	6	**1883–86**	7
1900–01	22	1892–95	7
Mean	10		9.2

Bold-faced type indicates the periods in closest agreement with the Brückner epochs of maxmum and mimimum temperature.

The *warm years* of the Brückner Cycle in the nineteenth century are 1830, 1865, and 1900. The actual variations for these years, including the five years on both sides of the central year, were as follows:

1830—the ten years 1821-30 were the warmest in the one hundred years considered and, therefore, it may be said that there is perfect congruence between the actual figures and the expectation of the Brückner Cycle.

1865—this period was only partially verified. The five years prior to 1865 on the average were but slightly warmer than the average, those subsequent to that year were exactly average.

1900 partly verified. The year 1900 itself was warm as was also 1901, though in a lesser degree.

The Brückner *cold years:* these were 1815, 1850 and 1885. Of these the first named only was fully justified although the coldest three years of the century occurred just ten years later. 1850 must be classed as a failure considering the ten years 1846-55. Two years later in 1856-7 a marked fall in temperature occurred.

The ten year period 1881-90, was just about normal, though for the three years, 1883, 1884 and 1885 there was a small negative deviation.

Summarizing the agreements and disagreements in temperature we get the following exhibit:

TABLE 2. Temperature Periods

	Verified	Partly verified	Not predicted
Warm	2	1	8
Cold	1	1	9

PRECIPITATION.—Since there are a number of precipitation records in the United States that evidently were not available to Brückner forty years ago and, moreover, since a number of new rainfall stations have been established since that time (1885), I have thought it worth while to compute afresh the five-year averages of precipitation for all available stations as published in Weather Bureau Bulletin W (revised edition).

In all I have used the records of 238 stations whereas Brückner had but 41 as a maximum. Combining the records of even 238 stations into a general mean which shall represent an area as great as that of continental United States is fraught with more or less uncertainty and is to be avoided; therefore I have divided the total area of the United States into four rectangular parts, not by any means equal in area. The east-west dividing line runs from the border between Virginia and North Carolina westward to the southeast corner of Colorado, thence west to the Pacific near the 40th parallel; the north-south line closely parallels the 100th meridian of West longitude. Thus it will be seen that the eastern sub-divisions are greater than the western.

The results of this compilation are embodied in Table 3.

TABLE 3. Five-Year Precipitation Means in U. S. 1806-1920

	1806–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80	81–85	86–90	91–95	96–00	01–05	06–10	11–15	16–20
No. of Sta. (Bruckner) U. S.	1	2	3	3	8	11	20	27	25	35	41	35	31	36	32	32	...	...	...	...	...	...	...
No. of Sta. (Henry) NE U. S.	1	2	3	4	13	19	28	34	36	42	56	62	60	97	106	115	124	129	131	131	132	131	130
No. of Sta. (Henry) NW U. S.	...	...	...	...	...	...	...	...	...	2	5	5	4	15	18	25	24	30	30	32	32	32	30
No. of Sta. (Henry) SW U. S.	...	...	...	...	...	...	...	...	...	4	7	1	5	16	17	12	16	19	19	20	21	20	19
No. of Sta. (Henry) SE U. S.	...	...	...	...	...	...	1	8	8	12	13	6	6	29	31	36	46	54	55	55	53	55	57
Total—Henry	1	2	3	4	13	19	30	42	44	60	81	74	81	157	172	188	210	232	235	238	238	238	236
Mean dev. from av'g. (Bruckner) U. S.	...	...	...	...	2.4	−1.3	−2.8	−0.7	2.0	1.2	00	0.4	2.5	1.6	2.6	0.9	[14	−1.6	0.2	−0.5	−2.0	−0.8	−2.0]
Mean dev. from av'g. (Henry) NE U. S.	...	...	...	−3.0	2.0	−1.4	−2.0	−0.3	1.7	0.9	0.2	1.1	1.5	−0.8	1.9	2.5	1.2	−2.0	0.1	−0.4	−1.4	−0.9	−1.6
Mean dev. from av'g. (Henry) NW U. S.	...	...	...	...	...	...	...	...	...	...	−1.0	0.1	−0.3	−0.9	0.4	−0.6	−1.6	1.3	0.8	−0.7	0.4	−0.5	−1.4
Mean dev. from av'g. (Henry) SW U. S.	...	...	...	...	...	...	...	...	...	0.3	−0.1	−0.3	4.4	−0.5	−0.6	0.6	−0.4	−1.3	−1.2	−0.3	0.7	0.5	−0.8
Mean dev. from av'g. (Henry) SE U. S.	...	...	...	...	...	...	...	−1.3	−2.5	1.0	−1.0	0.6	0.3	2.8	3.2	4.4	2.7	−1.1	−1.1	−1.9	−2.4	−0.1	−0.1
Composite mean U. S. (Henry)	...	...	...	...	...	...	...	...	...	...	−0.4	0.4	1.7	0.4	1.5	1.8	0.7	−0.9	−0.2	−0.8	−0.9	−0.4	−1.1

Figures within square brackets were computed by the author from the original stations used by Bruckner up to 1885.

The precipitation records of the United States prior to about 1830 are entirely too few in number to determine even approximately the yearly distribution except for the immediate vicinity of the few stations reporting during those early years; consequently I am unable to prove or disprove the existence of a period of wet years about 1815 as postulated by the Brückner theory. The next group of wet years falls about 1850. Table 3 shows some evidence of heavy rains in the two four-year groups, 1846-50 and 1851-55; and it may therefore be considered that theory and evidence are in agreement. The Brückner wet period of 1885 was fully justified by the results in the table, whence it may be seen that instead of a single wet period of five years, there was an unbroken period of at least fifteen years with precipitation above the average. There followed an almost unbroken series of dry years up to 1926, although according to the Brückner theory a group of wet years was due in 1920.

As in temperature so in precipitation, years of high precipitation follow years of light precipitation, seemingly *without* law or order. Table 4 next following shows that at Padua, Italy, in a period of 174 years there were 23 wet groups with an average interval of 7.6 years, and at Edinburg, Scotland in a record of 112 years there were 12 wet periods separated by an average interval of 8.5 years.

TABLE 4. Groups of two or more wet years at PADUA, ITALY, 1727-1900 and EDINBURG, SCOTLAND, 1785, 1896. The wet periods of the Brückner Cycle fall about 1745, 1780, 1815, 1850 and 1885.

PADUA		EDINBURG	
Group No.	%	Group No.	%
1 1727-31	120	1 1789-92	118
2 1733-34	107	2 1794-95	127
3 1744-46	113	3 1808-12	113
4 1748-49	114	4 1822-24	105
5 1751-53	118	5 1827-30	118
6 1755-56	122	6 1836-38	118
7 1758-61	118	7 1845-48	106
8 1763-65	116	8 1859-68	111
9 1769-73	144	9 1871-74	116
10 1775-77	118	10 1876-77	139
11 1785-86	114	11 1881-82	113
12 1793-95	112	12 1894-95	106
13 1798-00	116		
14 1801-07	122		
15 1809-10	120		
16 1835-37	109		
17 1844-46	122		
18 1850-51	115		
19 1855-56	125		
20 1868-69	116		
21 1872-73	117		
22 1876-78	112		
23 1895-96	124		
Mean	118		116

A paper on "The wet summer of 1924 and other wet seasons in the British Isles" by Mr. John Glasspoole has just appeared in the October 1926 number of the *Quarterly Journal* of the Royal Meteorological Society from which the following is taken. Since 1868 there have been five wet years, viz, 1872, 1877, 1882, 1903 and 1924; the percentage of the normal registered in those years was 137, 127, 120, 127, and 117. Thus they were unmistakably "wet." The average interval was about nine years, although three of them were separated by an interval of but five years.

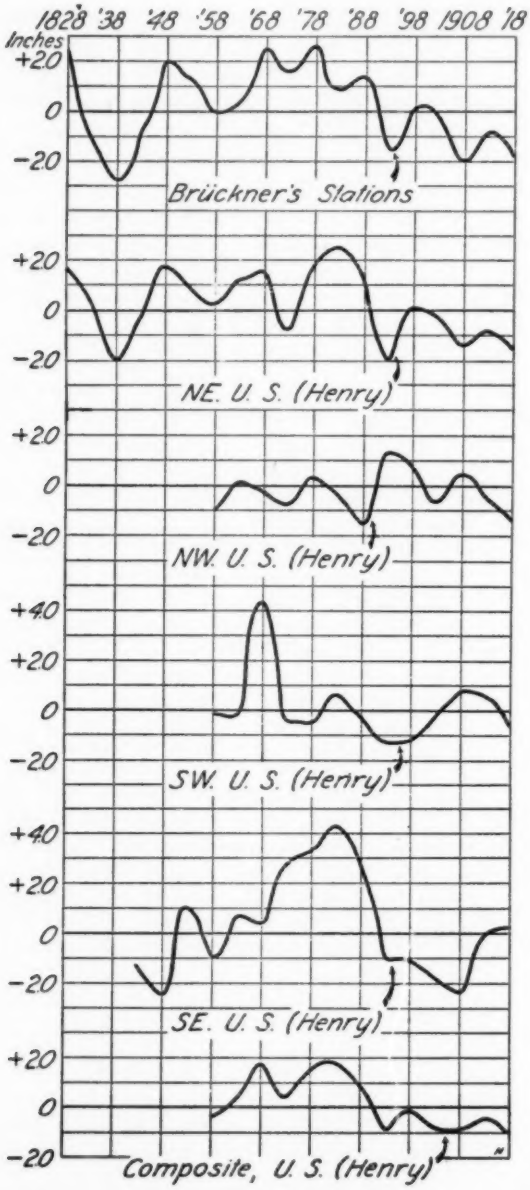

Fig. 1. Secular Variation of Precipitation in U. S. on Basis of Yearly Means

The results of Table 2 have been plotted to form the curves of Figure 1. The top curve in that figure represents the secular variations as deduced from the stations available to Brückner in 1885, the period subsequent to that year having been supplied by the writer using the identical stations that were used in forming the earlier part of the curve. The second curve from the top was formed from the results for Northeastern United States, and the curves following are sufficiently identified by their titles.

In order to distinguish between the results derived from five-year means and those of single years I have computed the variation from the normal for each year since 1884, using only the principal stations of the Weather Bureau, about 200. The results are graphically shown in Figure 2.

The most striking result that comes from Figure 2 is that out of the forty-two years but three of them had above the normal precipitation and in two of these the excess was so small as to be of little consequence.

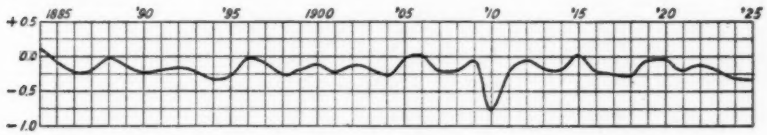

Fig. 2. Secular Variation of Precipitation in U. S. on the Basis of Five-Year Averages, 1885 to 1925.

Evidence of Lake Levels and Floods in the Large Rivers of the Interior

Lake Levels.—Measurements of lake levels in the United States are available for the Great Salt Lake of Utah, and the Great Lakes. The records for the first named for the early years are, however, but little better than tradition and for reasons that cannot be entered upon in detail the record of changing level in Lake Superior is the only one of the Great Lakes that can be used in this study.

The table below shows the years of occurrence of high water and low water during that part of the record when reliable measurements were made.

	High Water	Low Water		High Water	Low Water
Great Salt Lake	1855	1851	Lake Superior	1862	1879
	1873	1861		1876	1911
	1886	1883		1900	1925
	1910	1905		1916*	
	1923	1920			

There is little in either record to indicate a common control of the fluctuations or that they are in step with the Brückner oscillations.

* The maximum in 1916 was doubtless due to the installation of regulatory works at the outlet of the lake.

FLOODS IN THE LARGER RIVERS OF THE INTERIOR.—Through the courtesy of Dr. H. C. Frankenfield, River and Flood service of the Weather Bureau, I am able to present a chronological list of the major floods in the interior drainage of the United States, mostly the Mississippi and its chief tributaries.

It is obvious that great floods often occur in groups of years separated by a small time interval. I have, therefore, bracketed those floods which may be considered as belonging to the same period, and thus it appears that in the period of 164 years twelve major flood periods were experienced or one in each fourteen-year period.

The Brückner epochs of both wet and dry years were productive of great floods in the interior rivers; therefore we may say that the data of floods neither prove or disprove the reality of the Brückner Cycle.

TABLE 5. Years with Great Floods in Interior Drainage of United States

Years	Year	Years	Year
1762	1844	1881	1907
1763	1847	1882	1912
1785	1851	1884	1913
1787	1857	1892	1915
1810	1867	1897	1916
1832		1903	1922
			1926

THE DISTRIBUTION OF HEAVY RAINS.—The normal distribution of heavy rains is always more or less local; rarely or never is there a period of intense rains over an area of large geographic extent, say one hundred thousand square miles. A study of the regional distribution of heavy rains in the interior points to the fact that no single extraneous control seems to be operative to produce these rains, but rather that the fortuitous juxtaposition of certain pressure formations over any particular region must be the cause of heavy rains. A pressure formation that will cause a massive current to flow from the south over a region that is about to be dominated by an equally massive current from a northerly quarter seems to be the most effective as a heavy rain producer. Such a condition featured the heavy and prolonged rains over the Ohio Valley both in October 1910 and in March 1913 and similar pressure formations result in heavy rains over the southern Plains States in spring.

In the view of the writer it would seem that the elements that conspire to withhold rain on the one hand, or to give it in generous quantities on the other hand are always present; the chief difficulty and the reason why heavy rains are infrequent is because of the lack

of the energy necessary to produce a strong ascensional movement of a considerable volume of warm moist air.

Dr. Geo. C. Simpson has recently[5] drawn attention to the thermal stratification of the atmosphere. By using the idea of entropy he has shown that the atmosphere can be marked off into nearly horizontal shells which have the peculiar property that air which starts in any one shell cannot be transferred to any other shell and remain there unless heat is added or subtracted.

It is only on rather infrequent occasions that the air in spring and fall contains sufficient water vapor to supply, when it condenses, the heat necessary to pierce the thermal stratification that is present in the atmosphere the greater part of the time.

Conclusions

Dr. Brückner has shown that climatic oscillations occur which cannot be classed as accidental. His work however, terminated at a time when observations of temperature and rainfall were being made with increasing care and in a larger number of places than ever before.

It is now possible to make a survey of the temperature and rainfall distribution the world over, the results of which would have greater value than those of forty years ago.

The known distribution of temperature and precipitation teaches us not to expect years of heavy rain uniformly distributed over large areas, or of uniformly high or low temperature similarly distributed, although the chance of a uniform distribution of temperature over a large area is considerably greater than that of uniform distribution of precipitation.

This study for the United States has shown that by using definite observational material for a large area, a number of epochs of maxima and minima come to light, some of which fit into the Brückner Cycle, but many do not.

LITERATURE CITED

(1) Brückner, Eduard.
1890. Klimaschwankungen seit 1700 nebst Beobachtungen uber die klimaschwankungen der Diluvialzeit. Wien, 1890.

(2) Clough, H. W.
1905. Synchronous variations in solar and terrestrial temperature. Astrophysical Journal, **22**: 42-75.

(3) Brückner, E.
1915. Memorial Volume. Transcontinental Excursion of American Geographical Soc., New York, 1915, p. 127.

(4) Henry, Alfred J.
1923. Sunspots and Terrestrial Temperature, Mo. Wea. Rev. **51**: 243-49.

(5) Simpson Geo. C.
1925. New Ideas in Meteorology. Abstracted in *NATURE*, London, Aug. 29, 1925.

(6) Hamberg, H. E.
1906. Kungl. Svenska Vetenskapsakademiens handlingar. Band 40. No. 1. pp. 1-15.

DEVICES FOR ACCUMULATING GEOGRAPHIC DATA IN THE FIELD*

By D. S. WHITTLESEY

History of the Topic.—It is only a little more than ten years since students of Human Geography in the United States began to publish specifications for field study in their subject.[1] For some time public discussions of field technique remained theoretical in tone,[2] and it has been less than two years since results of practical experiments first came from the press.[3]

Viewpoint of this Paper.—The following paragraphs are intended to verify the utility of field practices hitherto suggested, to outline additional methods that have been tried out, and to stimulate still further the elaboration of field technique.

Although it is hoped that the conclusions stated may have general application, they are drawn chiefly from the experiences of a field party which spent August, 1926, in making a detailed geographic study of a locality about eighty square miles in extent, at the northwestern base of the White Mountains (Lancaster, New Hampshire, on the Upper Connecticut River).

Preliminaries to Entering the Field.—Proper introduction to inhabitants of the region has been found prerequisite to obtaining the best results. Letters of introduction to community leaders give direct access to invaluable aid, and these should be numerous, since many such persons are out of town during the summer (the period best suited to field work), and others do not interest themselves. The local newspapers afford the best means of reaching the general public. Explana-

*Read before the Association of American Geographers at the Philadelphia meeting, Dec. 29-31, 1926.

[1] Jones, W. D. and Sauer, C. O.: "Outline for Field Work in Geography"; *Bulletin of the American Geographical Society* XLVII (1915), 520-5.

[2] Culminating in the comprehensive article by Sauer, C. O.: "The Survey Method in Geography and its Objectives"; *Annals of the Association of American Geographers* XIV (1924), 17-33.

[3] Jones, W. D. and Finch, V. C.: "Detailed Field Mapping in the Study of the Economic Geography of an Agricultural Area"; *op. cit.*, XV (1925), 148-57.
Whittlesey, D. S.: "Field Maps for the Geography of an Agricultural Area"; *ibid.*, 187-91.
The following titles apparently complete the list of American publications on field theory in Human Geography.
Sauer, C. O.: "Proposal of an Agricultural Survey on a Geographic Basis"; *Michigan Academy of Science, 19th Annual Report* (1917), 79-86.
——— ———: "Mapping the Utilization of the Land"; *Geographical Review* VIII (1919), 47-54.
Parkins, A. E.: "The Teaching of the Geography of a Small Area"; *Journal of Geography* XIX (1920), 130-40.
Davis, D. H.: 'Objectives in a Geographic Field Study of a Community"; *Annals of the Association of American Geographers* XVI (1926), 102-9.

tory items about the party and its objectives, published in advance of arrival, disarm suspicion and arouse a curiosity which brings about active cooperation. Reports of progress as the work goes on are valued by the newspaper and insure to the geographer continued assistance.

It may be assumed that all pertinent material generally available will be taken into the region to be studied. Among such data maps rank first in importance, partly because the information they contain is areally distributed, and partly because they can be used as bases for the collection of further material. A first-class topographic map is the most valuable sort for use as a base, but failing this, coast or river survey maps, land ownership maps, road maps, or even county maps may be utilized. For urban districts street maps on a large scale will serve admirably. Besides these, any other maps which distribute items either of the natural environment or of human occupation, such as soil, forests, telephone lines, land values, are so many short-cuts to the geographer's goal.

Statistical compilations are only less valuable than maps. Tables covering climate, vital statistics, land values, and traffic volume for even small localities are likely to be published by one or another governmental agency. Special reports on local conditions, such as farm economy or manufacturing sites, may exist, and if so can be procured in advance by applying to superior and local governments, and to local organizations of business men. Some books bearing a commercial imprint, especially local histories, may be found in the larger libraries.

Equipment varies with the individual geographer and with the conditions under which he must work. For the detailed study of a locality a number of field workers have found the following items all but indispensable:

notebook, containing plain, cross-section, and tracing paper;
pencils of a dozen different colors, as well as hard black pencils fitted with erasers;
compass, plane table, ruler alidade, and ruler protractor;
soil auger, soiltex (or some other simple acidity test);
camera and tripod.

Devices for Compiling Data Gathered in the Field.—Thus fortified by introductions, compilations, and equipment, the geographer enters his field of study to gather additional material.

At the outset he can begin to assemble observable facts on field maps, and these maps become the most valuable items in his collection of data. They portray two groups of facts: (1) the cultural complex—routes of transportation, buildings, crops, mines, and wastes; and (2) the environmental complex—combinations of slope, drainage, soil, and

plant associations, to which native animals and climatic variations may be added if observable and important. Some workers employ only one field map, for the sake of convenience, whereas others use two, for the same reason.

The smallest scale which permits detailed distributions in rural areas seems to be four inches to the mile, and in urban areas twelve inches to the mile. Legends used for the maps of the Lancaster locality are appended to illustrate the kinds of facts mapped. It will be noted that the several environmental complexes are designated by non-committal letters. This has been done because the attempt to define environmental complexes is in the pioneer stage, and as yet generalizations can not be made to cover more than a single region. Examples of rural maps may be found in the articles referred to in footnote three above.

TABLE 1. Key to Field Map of the Rural Cultural Complex

Land in Field Crops	Tilled—yellow Bog Hay—yellow with gray dots
Land in Pasture	Clear—orange Wooded—orange with green dots
Land in Woods	Pastured Woodlot—green with orange dots Timber Land—green
Idle Land—gray	
Farmsteads—pink	
Urban Land—pink on rural map	
Routes	Railroads—+—+—+—+—+—+—+—+ Main Highways for Through Traffic——— Farm Roads, Surfaced ———————— Grassy Dirt Roads.....
Public Utilities	Telephone Lines—T T T T Power Lines—P P P P Water Mains—W W W W

TABLE 2. Key to Field Map of the Urban Cultural Complex

Commercial Land—red
Manufactural Land—purple
Transportation Land—black
Public Land—brown
Residential Land—pink
Saxicultural Land—white

TABLE 3. Key to the Field Map of the Environmental Complex

(Details of soil profiles and plant associations are omitted in the following abridged descriptions).

Type A—orange.	Flats almost at stream level, with boggy surface, peaty soil, and bog hay cover.
Type B—yellow.	Flats 10-30 feet above stream level, with rapid underdrainage, sandy silt soil, grassy vegetation.
Type C—red.	Similar to Type A, except for tree cover of alder-tamarack.

Type D—black.	Undulating to hilly, with pebbly, sandy soil, blowing where exposed, very rapid drainage, and pine or blueberry-fern cover.
Type E—violet.	Undulating, well drained, with sandy-silt soil underlain by gravelly-rocky subsoil, and covered with spruce-birch or fern-grass plant associations.
Type F—green.	Steep slopes (10°+), soil similar to Type E, runoff rapid, some localities springy and wet, spruce-pine-balsam or spirea-fern or bog hay plant associations.
Type G—purple.	Gentle to moderate slopes (to 10°), soil similar to Type F but thicker, rapid run off, maple-birch or yarrow-grass associations.
Type H—gray.	Flats on compound mountain slopes, peaty soil with many boulders, slow drainage, varied plant associations.
Type J—brown.	Level or gently sloping shoulders and crests, thin soil with bedrock outcrops, rapid drainage, deciduous forest or scant grassy growth.

Photographs rank second only to maps in visual representation of geographic conditions. Three types of photographs appear to be most

The camera best suited to most field work probably is the bellows type, taking roll films with exposures 3¼ by 4¼ inches in size. Since pictures must often be taken in adverse weather and on short notice, a clear lense and a fast shutter are indispensable.

It is wise to postpone photography until a definite notion of scenes needed is in mind. This rule must be modified if any ground is to be traversed only once, or if, in a region subject to dull skies, ideal weather for pictures should occur early in the field season. In a section of the notebook reserved for the purpose, an explanatory key to all photographs specifies the location of the view, the objectives sought in taking the picture, and inconspicuous details of particular significance.

Systematic questioning is a necessary supplement to observation, because certain facts required for an understanding of the geography of any area are not observable by the most skilled worker. In so far as these questions can be classified they may be incorporated into questionnaires. Groups to which separate questionnaires may well be submitted are farmers, merchants, manufacturers, transportation men, clergymen, bankers, and teachers. The following excerpt of that used among the farmers of the Lancaster locality may serve as an illustration. In time some minimum list of questions generally applicable to each group may be formulated, but at present safe procedure dictates that an experimental set be worked out for each region.

TABLE 4. Sample of Questionnaire for Farmers

NAME OF FARMER	TOTAL ACREAGE	CROPLAND, ACREAGE					OUTPUT			PASTURE ACREAGE	WOODLAND		FERTILIZER		SEED	
		HAY	OATS	CORN	POTATOES AND GARDEN	FRUIT	HAY	OATS	ETC. AS BEFORE		ACREAGE	KINDS OF TREES	KIND	AMT.	KIND	AMT.
E. J. Wilson.....	110	40	.....	.....	.....	25 apple trees	50T	150 bu.	.....	20	16	Usual 300 sugar maple	Manure	150 loads	Hay	10 bu.

	CATTLE					SHEEP	HOGS	HORSES	CHICKENS	SUPPLEMENTARY FEED BOUGHT ANNUALLY	LABOR	
	COWS	YOUNG STOCK	TESTED	MILK							AMOUNT	SOURCE
				AMT.	MARKET							
E. J. Wilson...	16	2	No.	3 cans cream	Turner Center	20	2	4	50	3 T. hay 50 T. meal	1 man by yr. 1 man part time	Local

	NUMBER IN FAMILY		ORIGIN OF FAMILY	HOW LONG SETTLED HERE	LOCATION OF CHILDREN	DO THEY RETURN AFTER SCHOOLING	NUMBER OF SUMMER BOARDERS	REMARKS
	ADULTS	CHILDREN						
E. J. Wilson.....	6	0	Man local; wife N. Y. State	.....	1 Lowell 1 Hartford 1 Whitefield	For visits	None	Makes no sugar

Certain comparable groups of facts may profitably be scored or rated. In so far as this can be done from observation, it is a field job. The quality of types of buildings—farmsteads, urban homes, stores, factories—lends itself especially well to scoring. The device worked out for farmsteads in the Lancaster locality illustrates the sort of analysis that may be made.

TABLE 5. Score Card for the Evaluation of Farmsteads

ITEM OBSERVED	QUALITIES RATED	MAXIMUM SCORE IN POINTS*
House.....	Size.	1
	Style and construction.	1
	State of repair.	1
	Grounds, plan and upkeep.	1
Main Barn.....	Size.	1
	Style (ratio of volume to roof area, arrangement, lighting).	1
	State of repair.	1
	Grounds, plan and up keep.	1
Other Items.....	Buildings, fences, machinery, water supply.	1

*Any of the qualities listed may be given a fractional score, preferably ½, ¼, or ¾.

Ratings of unobservable facts, such as size of farms, volume of traffic, output of factories, may be made from the completed questionnaires, and hence need not be done in the field. Nevertheless, if made on the ground, such comparisons are likely to lead to further investigations that otherwise would not suggest themselves. Scores of all sorts may be entered on either the field maps or the questionnaires.

Even though all classifiable information has been digested into maps, questionnaires, and scorecards, many useful facts will remain unsorted. These can only be entered in the notebook. If a loose-leaf book be used, and no more than one note placed upon a sheet, such items can readily be distributed to their proper position among the raw materials for the report on the area. Where notes refer to specific places, key numbers will serve to relate them to appropriate maps in such a way as to contribute to the distributive knowledge of the region. The chief sources of this sort of information have been found to be (1) local depositories, such as the library, town or city hall, courthouse, office of the farm agent, chamber of commerce, business men's club, and business office; (2) conversations with well-posted people, either officials

like the farm agent and the school superintendent, or individuals such as bankers and clergymen; (3) odds and ends of observation and questioning in the field.

Before leaving the locality, the wise worker will carry the organization of his material at least to the stage of a detailed presentation outline. This procedure will disclose gaps in information that would otherwise pass unsuspected, and it probably will suggest fresh lines of investigation which can be undertaken only in the field.

Range of Application of the Methods Outlined.—The foregoing statement of devices for accumulating geographic data in the field has been made to fit a detailed chorographic study. For reconnaissance surveys the same devices might well be used, but with less attention to detail, and with a less thorough canvas of conditions. It should not be difficult to evolve abridgements in the method, once the technique has been worked out for intensive studies.

A CLASSIFICATION OF MANUFACTURES, EXEMPLIFIED BY PORTO RICAN INDUSTRIES*

ROBERT S. PLATT

INTRODUCTION.—The purpose of this article is to present a classification of manufactures from the geographic viewpoint. It is a reaction against the slighting of manufacture in geographic work on the assumption that it is of less geographic consequence than other industries, and a protest against the publication of unassorted and uninterpreted lists of manufactures as if such lists were of geographic consequence. Manufacturing is related to the natural environment less directly and simply but not necessarily less significantly than other industries. It is located within wider or less tangible limits of human choice, but yet real and finely distinguished limits. The term manufacture is not sharply defined and covers various kinds of activities. Therefore, an unassorted list of manufactures can hardly escape confusion in grouping together things of very diverse significance. Definition, analysis, and classification are needed.

Porto Rico has been chosen for investigation, first, because it is a separate island unit; secondly, because its manufactures are distinct but less complicated than those of highly developed manufacturing districts, and thirdly, because its manufactures are recorded completely and indiscriminately in unassorted lists,—colorless material to which classification and interpretation may give geographic color.

Porto Rico is not classed as a manufacturing country. Yet 75 per cent by value of the exports of Porto Rico are classified as "manufactured," and there are many other commodities manufactured and not exported. This apparently anomalous situation results from the fact that the term "manufacture" is used with both broad and narrow meanings and therefore at the outset calls for definition.

In a broad sense the term applies to any part of the series of processes by which raw materials are changed and combined from their original production to the final consumption of the finished product, whether or not the necessary labor is carried on in factory buildings or is aided by mechanical means. The series of processes may be very short and simple, or very long and complicated, the finished product of one manufacturer becoming the raw material of another.

In a narrow but at the same time a less definite sense, manufacturing is thought of only in connection with complicated processes carried on by machinery and organized groups of laborers, especially in industries for which power, labor, and transportation are important local-

*Read before the Association at the Philadelphia meeting Dec. 29-31, 1926.

izing factors. In this sense, simple processes of preparing commodities for consumption are not considered as typical manufacturing; nor is every stage of a complicated series of processes so considered. Preliminary processes at the beginning, closely connected with the original production of material, may be considered a part of agriculture or mining; and final processes at the end, close to consumption, as a part of household utilization. Intermediate processes, carried on mechanically at factories located at transportation centers, or at labor or power centers, are the distinctly manufacturing industries, and give rise to typical manufacturing districts.

In the light of these distinctions it is easy to classify the industries of Porto Rico. Presumably the principles involved may be applied elsewhere, even though the form of classification may need modification.

THE GROUPS DEFINED.—In the accompanying table industrial establishments of Porto Rico are grouped according to factors that affect their presence in the island. For Group I the principal raw materials are produced in Porto Rico and the markets are elsewhere. For Group II the market is in Porto Rico and the principal raw materials are imported. For Group III both the market and the sources of materials are in Porto Rico. For Group IV neither the market nor the sources of materials are in the island, and Porto Rican labor is an important factor.

The table is evidence of the fact that Porto Rican industries are varied in their relations, and that geographic significance is not to be measured by value of products nor by alphabetical order in an undivided list. Details of geographic adjustment are brought out by further analysis of individual industries in each group.

TABLE I. MANUFACTURES IN PORTO RICO

Group I Porto-Rican Materials, Foreign Markets	Group II Foreign Materials, Porto Rican Markets	Group III Porto Rican Materials, Porto Rican Markets	Group IV Foreign Materials, Foreign Markets
Sugar mills Tobacco factories Coffee establishments Fruit canneries Copra kilns Bay oil distilleries Cotton gins	Bakeries Printing and publishing shops Foundries and machine shops Boot and shoe factories Clothing factories Flour and grist mills Car shops Planing mills Marble works Millinery factories Trunk factories Mattress factories Wagon shops Furniture factories	*A. Close to markets* Ice factories Soda water bottling plants Potteries *B. Close to materials* Lime kilns Brick and tile yards Salt ponds	Embroidery and drawn work agencies Straw hat and basket agencies

Group I

Sugar Milling.—The leading industries of Group I have to do with products of agriculture. These industries supply most of the exports of Porto Rico, the one commodity sugar making up 60 per cent by value of the export total. The island is conspicuously agricultural and sugar cane is the leading crop, occupying most of the fertile level land and engaging as farm laborers more people than any other occupation.

It is taken as a matter of course that not only is sugar cane grown in Porto Rico, but also that the raw material is made into sugar there. There are 55 sugar mills in the territory representing an average investment of more than $1,000,000 each, and sending out annually a product valued at almost $1,000,000 each.

That this industry should be carried on in Porto Rico instead of having the raw material exported is natural for compelling reasons. Sugar cane deteriorates rapidly after being cut, losing two per cent or more of its recoverable sucrose every day after the first 48 hours. Therefore it is not economical to delay it on the way to the mill. Moreover, about 89 per cent of the cane is waste matter, and it is not economical to transport ten tons of cane farther than necessary to obtain little more than one ton of sugar. This in itself is a sufficient reason for the distribution of the sugar mills around the island, each in the heart of its own cane fields, rather than concentrated at shipping points or labor markets. A mill site on a harbor for shipment of products and receipt of minor materials is only a secondary consideration, accepted as an advantage if found within the cane area, but not chosen at a distance in preference to the cane area. Concentration of the industry has proceeded only to secure the efficiency of large scale operation, in central mills, each in the midst of an area formerly served by five or more small mills, grinding much faster and extracting 40 per cent more sugar. These mills are classed as factories and their products as manufactured goods. Yet in their location, their organization, and their operation they are inseparably connected with Porto Rican agriculture; they represent a manufacturing development in the broad but not in the narrow sense.

In their utilization of a perishable material, sugar mills are like cheese factories, which are located in the heart of dairy country, and like vegetable canneries, located in the heart of truck-farming country. In their elimination of waste material they are like lumber mills located close to forests, and like ore-concentrating plants located close to mines.

The sugar is not refined in Porto Rico. This fact is hardly less natural than that the cane is crushed in Porto Rico. In the series of processes between cane production and sugar consumption, there is some economy of transportation in making sugar close to the cane fields and in refining it close to the market. Raw sugar requires less care in handling than does the refined product, and is shipped from many centrals to a few large refineries in the United States for storing, refining, and distributing according to market requirements through the year.

The tendency to refine the product away from Porto Rico is strengthened by other factors, particularly the advantages elsewhere of power and capital. Obviously the localization of this and other industries is not fixed simply in relation to raw material and market. If there is only a slight margin of advantage in transporting before or after fabrication, other factors—power, labor, capital—are likely to be critical.

The advantages in favor of refining sugar elsewhere may be overbalanced by the cost of bagging raw sugar for shipment, and to eliminate this item, as well as to supply the local market, there may be an increasing development of refining in Porto Rico.

Sugar milling gives rise to certain by-products, and the first processes connected with these fall naturally into the same group of industries. Some final molasses is exported for the production of alcohol. Crushed cane refuse, bagasse, is used as fuel in the sugar mills, being a valuable substitute for imported fuel. In general sugar milling processes appear as manufacturing in a broad sense, closely connected with the agriculture of the island.

Coffee Cleaning.—The coffee industry illustrates the same tendency toward preliminary manufacturing processes carried on in Porto Rico to improve carrying quality. Coffee is the leading crop of the rugged interior of the island. It occupies more land and engages more farm laborers than any other commercial crop except sugar cane. Coffee is the chief export of Porto Rico to countries other than the United States.

Treatment is necessary before exportation. The coffee beans, contained in "cherries," covered with useless pulp and subject to deterioration, must be pulped, fermented, washed, dried, hulled, sorted, sized, and polished to eliminate waste matter, fix the elusive flavor, and standardize the product. Methods of performing these operations differ greatly, the small producer doing by hand work that in large establishments is accomplished mechanically.

In many cases the first four processes are performed on the plan-

tations and the last four in the larger establishments in port cities. The first four processes are those which eliminate most of the waste matter and prevent deterioration, and these are carried on near the coffee groves, just as cane is crushed near the cane fields. Following these processes the coffee is readily transportable any distance with at least as great facility as later after the removal of the protective coat of parchment and the cleaning of the product. In this respect it is like raw sugar, and the last four processes may be compared with the refining of sugar.

That these latter processes are carried on in Porto Rico rather than nearer the market may be explained by the character of the coffee industry in contrast with the sugar industry: (1) the coffee, unlike sugar, is a distinctive Porto Rican product prepared in a distinctive Porto Rican way; (2) it is distributed directly to various foreign markets which demand this product; (3) it is more valuable for its bulk than sugar, and can bear a greater cost for careful handling; and (4) the processes of hulling, sorting, sizing, and polishing are easily accomplished by wholesale dealers in connection with their handling of the product without much equipment or labor.

These latter coffee processes may be considered as belonging to a class of industry different from the earlier plantation processes and from the sugar milling industry in that they do not prevent deterioration nor eliminate waste but add finishing touches for market. They are not in the producing area but in ports on the Porto Rican coast, conveniently located to collect from the producing area and to distribute to various countries, in contrast with the sugar refineries on the American coast collecting from various countries and distributing within one country. However, these coffee processes are so simple that certainly they constitute manufacturing only in a broad sense.

A wrong impression of the magnitude of these processes is given by the total value of their product, more than $11,000,000 annually, second only to sugar milling. More than 95 per cent of the value of the coffee is due to the production of the crop and to the plantation processes, and less than 5 per cent is value added by manufacture[1] in the cleaning and polishing establishments. This fact serves to indicate how unsatisfactory is the total value of the product as an index to the importance of a manufacturing industry.

Tobacco Manufacturing.—Tobacco, third in the triumvirate of great Porto Rican crops, gives rise to industrial activity which exceeds

[1] In U. S. government statistics the cost of power is included in "material" and not in "value added by manufacture," but this is so small an item as to be of little significance in coffee preparation and in other Porto Rican industries with the exception of ice making.

coffee preparation in value added by manufacture and is second only to sugar.

The preparation of leaf tobacco is comparable to that of coffee. The first process on the plantations is relatively simple, consisting in hanging the plants in specially constructed sheds to dry for three or four weeks. This is followed by fermentation in storehouses; then soaking, drying, baling, stripping, classifying, bundling, barrelling, seasoning.

As in the case of coffee, the latter processes are carried on for the most part in the establishments of dealers in port cities, and have to do with bringing out the distinctive quality of a distinctive Porto Rican product. The processes are somewhat more elaborate than in the case of coffee so that the business tends to become more of a separate industry apart from distributing. Moreover, most of the leaf is exported to the United States rather than being distributed to various countries. But there is still reason enough for carrying on this activity in Porto Rico, as is coffee cleaning, rather than in the United States, as is sugar refining, because these processes are important in fixing the quality and compacting and protecting the product for shipment, and therefore belong close to the agricultural industry.

There is a further stage in tobacco preparation which has quite a different significance from either the preliminary or the later processes of leaf treatment. Most of the Porto Rican tobacco is exported in leaf form, but there is some local manufacture of cigars and cigarettes. This industry takes the prepared material and from it makes a product which is less compact and more difficult to ship. The fact that the product is more valuable than the raw material does not account for its manufacture in Porto Rico. Other reasons than the production of material prevail, and, in this respect, the industry does not belong in Group I. Most of the cigarettes are for the local market, thus attaching part of the industry to Group III. Most of the cigars are for export under circumstances which point to Group IV, to be discussed later.

Fruit Canning.—Fruits, which are fourth in importance among the commercial crops of Porto Rico and are the chief product of American settlers in the island, differ from sugar cane, coffee, and tobacco in requiring no transforming processes. The packing and shipping houses are conspicuous establishments, but their work is that of transporting and not of manufacturing, their object being to arrange and forward the fruit to market in an unchanged condition.

However, a secondary industry, the canning of fruit, has grown up as an adjunct of the fresh fruit industry, another example of a manufacturing process in preparation for transportation to a distant market.

In the canneries, the perishable material is made into a nonperishable product more readily transportable. Surplus fruit, especially that which does not quite meet fresh fruit standards in grade and size, is material for canning. Lower transportation costs and a market widened and lengthened by the imperishability of the product thus make possible the export of a commodity not otherwise marketable. That the process belongs in the fruit growing territory is obvious.

The principal canned fruits are pineapples and grapefruits. Oranges, which are most plentiful throughout the island but least exportable on account of competition in the United States and the inaccessibility of much of the crop, have not been canned thus far for lack of a suitable process.

Copra Drying.—Coconuts rank next to fruits among commercial crops, and like fruits, they are transported preferably unchanged to market. Likewise, there is special treatment of a surplus not otherwise marketable. The making of copra is a simple process of drying the coconut meat, thus greatly condensing the product to be exported for oil production.

The relative proximity of Porto Rico to the United States is an advantage in reaching the market for fresh coconuts, less valuable by weight but more valuable by number. Consequently most of the Porto Rican crop is marketed fresh and copra making is a minor activity, far less important than on distant East Indian coasts.

Bay Oil Distilling.—Several minor crops induce small industries. Bay trees are grown in one district. From a hundred pounds of bay leaves a little more than one pound of essential oil is produced by distillation and decantation. This proportion of almost 99 per cent of waste matter to one per cent of product, together with the perishability of the crop, explains the location of distilleries in the two towns of the crop district.

A further process is the mixing of bay rum, containing a small portion of bay oil and a large portion of alcohol, a byproduct of sugar. This is not attracted to the bay crop district but to a convenient meeting place of the ingredients on the way to market. Much of the oil is exported to the United States for treatment, but some bay rum is made in Porto Rican ports.

Cotton Ginning.—A small amount of sea island cotton is grown in the island. Cotton gins are not commonly considered as factories, but they belong in the same class as the other establishments under consideration, separating the byproduct seed and making compact bales for shipment. Later cotton processes, which do not increase the mobility of the material, are not attracted to the producing area but are localized by other factors, not in Porto Rico.

Conclusion for Group I.—All of the manufactures of Group I take the raw materials produced locally by fundamental industries and prepare them as far as economically desirable to avoid uneconomical transportation. Most of them belong in the very districts within Porto Rico where the fundamental production takes place. Those processes which are carried on in port cities away from the producing districts are not typical of the group but verge on other groups, as illustrated by the final treatment of coffee and tobacco. This is to be expected in view of the fact that transportation from the producing district to the port is likely to be a costly part of the journey to market, in some cases the most costly part.

Distribution of the processes within producing districts depends to a considerable extent on the scale of the industry. If the manufacturing is organized on a much larger scale than the fundamental production, there is necessarily concentration within the district, manufacturing at a few points for production on many farms. This is illustrated by the sugar industry, in which the increased cost of transporting cane to a few centrals is much more than balanced by the decreased costs of large scale production. If the manufacturing is organized on as small a scale as the fundamental production, then the process is widely distributed; every farm has its factory. This is the case in the first treatment of tobacco and other commodities, merging into the fundamental production, and at its inception lacking separate identity as manufacturing even in a broad sense.

Group II

There is a much longer list of industries which do not produce export commodities and which largely import their raw materials. None of these are very large or very conspicuous. They are important in quite a different way from the group previously discussed, but are as easily accounted for. They are distributed not with reference to fundamental production but in relation to population centers.

A conspicuous illustration of these are bakeries, first in number of establishments, in number of workers, in value of products, and in value added by manufacture. Obviously this is an industry in which the finished product and not the raw material is perishable and difficult to transport. Manufacture must take place close to markets, which in this case are population centers in Porto Rico.

To a less extent the same thing is true of the manufacture of flour and meal, the raw material being somewhat more easily transported than the finished product. The advantage for flour mills is so much less impelling than for bakeries that only a small proportion of the

flour used in Porto Rico is milled locally, most of the supply being imported ready for the bakers from large American mills.

The small scale of the baking industry is indicated by the large number of bakeries, widely distributed in town and village markets, not centralized by any imperative advantages in large scale operation.

In the same class is printing and publishing, newspapers and periodicals, and jobbing. This is just as clear a case of perishable product for which the factory cannot be far from the market. In job printing there is also the element of direct individual service tying it to the market.

Foundries and machine shops are classed as factories, and, if they are to be considered such, they belong in this group. Their raw materials are imported and their markets are the local industries, for which they provide mechanical repairs and items of equipment. They are tied to the market not by the perishability nor by the greater bulk of the finished products as compared with the raw materials, but, like job printing, by the retail character of their service: instead of manufacturing to sell in an open market they are filling individual orders which need attention on the spot. Similar relations are evident in sheet metal shops, railroad car shops, planing mills, and marble works.

Makers of shoes, clothing, millinery, trunks, mattresses, wagons, and furniture have either or both of these reasons for their presence near the market, making their imported materials into more bulky products and in some cases performing direct individual service.

Most of these industries meet more or less competition from factories elsewhere, in proportion as the margin of advantage for local production is small or large: small for clothing factories, large for bakeries. The more typical of these industries are manufacturing in a broad sense. Extreme examples merge into individual neighborhood services.

Group III

The third group of industries has something in common with each of the groups preceding: it has both raw materials and markets close at hand.

Some of the industries of Group I have a minor phase belonging to Group III. A small proportion of the sugar crop is refined specifically for local distribution. Some coffee and some tobacco likewise are produced and used in Porto Rico. Ninety-eight per cent of the cigarettes made in Porto Rico are for the local market.

The distinct industries of Group III differ conspicuously from Group I in the character of their materials. Instead of being peculiar to Porto Rico and demanded by other countries, these materials are

so widely distributed and commonly available in the world as to be unsought and unused except for nearby markets.

Ice manufacturing is the first of the group, in number of persons engaged, in capital invested, in value of products,—in fact in every important particular except cost of materials. The general availability and cheap abundance of the only material used in large bulk is evident. The prime consideration is the tropical Porto Rican market for a product so perishable and bulky that there is little competition from outside sources.

Soda water bottling ranks second in the same group of industries. The product does not deteriorate, but, as in the case of ice, the bulk of the material is water, and transportation to market from a distance is uneconomical. Imported flavoring extract is of small bulk, and imported bottles can be reused, becoming a sort of circulating capital instead of part of the product. Until recently a brewery and a distillery were operated with the same advantage, their principal material by weight being water and their lesser materials, such as malt, being readily imported.

These industries are more closely tied to market than to source of raw material, since their products are less easy to transport than their materials. Pottery making is another example of the same sort.

Certain other industries in Group III are more closely tied to source of material than to market. Lime, brick, and salt are made for the local market from local materials. Unlike ice, these products are transported more easily than their raw materials.

These relationships to markets and sources of material are indicated by localization of the industries within the island: lime kilns are close to quarries, brick kilns close to clay pits, and salt ponds close to the sea. On the other hand, ice plants are in centers of population, and not at the sources of water supply.

Most of the industries of Group III, like those of Group II, meet some competition from imported manufactures. Production elsewhere with special materials or with advantages in other factors overcomes to a greater or less extent the advantage held by Porto Rican producers. Porto Rican pottery and salt are inconspicuous in the home market; while Porto Rican ice has practically a local monopoly.

Group IV

None of the first three groups of industries give Porto Rico standing as a "manufacturing" territory. The great sugar milling development is looked upon as a completion of the agricultural industry. Likewise coffee cleaning, tobacco stripping, fruit canning, are considered

adjuncts of agriculture, preliminary preparation of raw materials to be exported. Similarly, the other groups are looked upon not as distinct manufacturing but as activities of subsistence in modern life. Bakers, printers, machinists, cobblers, tailors, farriers, lime burners, stone cutters, accompany civilized groups of people everywhere in the modern world, without having special significance as manufacturers.

The idea of a manufacturing district seems to carry with it another implication: not preliminary preparation of raw material for shipment nor immediate provisioning of the local market, but fabrication dependent on other advantages, particularly power or labor.

Porto Rico has no coal, oil, or gas. It has some available water power as a result of heavy rains on abrupt mountains; but the small size of the streams in a country of such small water sheds offers the prospect of little surplus power beyond the ordinary needs of urban communities and densely populated farming country.

With respect to labor the situation is different. Porto Rico is one of the densely populated territories of the world, having almost four hundred per square mile, intelligent and poor people, needing work and not able to find it. The island is a market of cheap and fairly capable labor.

Labor without power leads naturally to hand industries without much machinery, inconspicuous and on a small scale. Thus production which seems to have some characteristics of a distinct manufacturing development is, to a large extent, household industry.

Embroidery, lace and drawn work are made in Porto Rico and have become familiar in American cities. The materials are imported and the product is exported. Porto Rican women have become skillful under instruction and are willing to work for wages which are very low according to American standards. The industry does not figure in the statistics of industrial establishments, but there are reported to be several hundred agencies, 22,000 persons engaged and exports valued at more than $6,000,000 annually.

A similar industry is the weaving of straw hats and baskets from palm leaves. This was based originally on production from local materials for the local market, and there is still this phase belonging to Group III. But it has grown beyond this into Group IV, with the importation of material and the exportation of hats of the Panama type, depending on cheap and skilled household labor.

Cigar making has been mentioned as not belonging typically to Group I, although most of the material is produced locally and 70 per cent of the product is exported. Cigar manufacture at a distance from the market, under a disadvantage in transporting the product,

depends for its success in large part on the labor factor. Cigars, more than cigarettes, are the product of cheap hand labor in shops large and small. The manufacturing of almost 200,000,000 cigars annually may therefore be classed with the making of embroidery and hats.

To say that these industries without factories, machinery or power, more truly than sugar milling, represent manufacturing in the narrow sense is perhaps taking too great liberties with an accepted meaning. Nevertheless these industries rest on foundations that tend toward distinct manufacturing, not adjuncts of agriculture or of urban life.

Porto Rico is relatively well developed so far as fundamental natural resources are concerned. Agricultural land is the chief of these and most of the fertile land is in use. Industries which depend closely on agriculture promise only small slow growth to accompany slight extension and intensification of agriculture. Industries which depend on the local market promise little more, since population cannot increase much further and since increase in per capita buying power is likely to be rather limited.

But there is surplus labor in quantity, and the utilization of this resource invites development of the types of manufacture in which cheap dextrous labor is the critical factor. Such development should tend to follow the lines already suggested by embroidery and cigars. Although it could not be great enough to overshadow the agricultural character of the country, nevertheless it should result in some prosperous enterprises and should help to some extent in solving the Porto Rican problems of unemployment and poverty.

LOCATION AS A FACTOR IN GEOGRAPHY

RICHARD HARTSHORNE[1]

INTRODUCTION.—The subject discussed in this paper developed out of previous studies presented in brief to this association.[2] In the study of the distribution of the iron and steel industry, and the study of the lake traffic of Chicago, it was found that relative location in its various aspects was the most important factor. Relief, soil, drainage, and even climate were of minor importance; the lake traffic of Chicago exists largely in spite of the nature of those factors at Chicago, and the distribution of steel plants is only locally affected by them.

Similar though more superficial studies of other manufacturing and transportation activities lead to much the same conclusion. In contrast with relative location, other factors—even such as climate in the cotton industry—are of very minor importance. In general, just as climate, relief, and soil are the major factors in agricultural geography; natural vegetation in pastoral geography and in forest geography; and the mineral resources in mining geography; so in the geography of manufacturing and transportation, relative location is the all-important factor.

Such studies of manufacturing have indicated a need for a general method by which we may determine the importance of the various factors which have influenced the location of manufacturing plants in particular places or districts where they are found—and which should determine the location of new plants. Consultation with economists and a brief survey of the literature in economics indicate that this task has been left to someone else—I have presumed, to the geographer.[3]

To avoid the confusion already perhaps apparent, due to different uses of the same word, the term "location" is used hereafter to indicate simply the act of placing a factory, or the fact that it is placed, at a certain point; situation in reference to other places—variously called relative location, geographic location, vicinal location, et cetera—will be referred to as "*locus.*"

---

[1] Read at the Philadelphia Meeting of the Association of American Geographers, Dec. 29-31, 1926.

[2] A much longer and more detailed treatment of this subject was written by the author for a different purpose and from a different point of view, and published in *Annals of Real Estate Practice*, 1926, *Vol. VII, Industrial Property*, (National Association of Real Estate Boards, Chicago, 1926), pp. 40-76.

[3] Studies of certain individual industries are to be found in Keir: *Manufacturing Industries of the United States*, but no general method is given.

OPTIMUM LOCATION.—Since most factories were formerly located without any *a priori* consideration of the advantages of different locations, some have accepted the obvious inference that there was no logic in their present distribution; in other words there could be no such thing as a science of industrial geography. But the same conclusion would appear even more justified in agricultural geography, whereas Baker and others have shown that experience teaches even ignorant farmers to plant, not whatever occurs to them, but those crops which make the most profitable adjustment. Similarly in manufacturing: iron smelting was started, at one time or another, in every one of the Atlantic states, but to-day is concentrated, not where it first started, but where the optimum location is found; much the same, as Keir has shown, is true of the cotton industry, and it could be shown for many others. However in certain types of manufacturing the so-called "advantage of an early start" is admittedly of major importance.

How is the optimum location for any industry to be ascertained? First, it is to be determined primarily on the basis of cost. Other elements, such as the marketing advantages resulting from the concentration of an industry in a restricted district, and the advertising value of the prestige of certain places, indicated by the significance of such terms as "Grand Rapids furniture," "Minneapolis flour," "Swedish steel," and the "made in Germany" label, these are today of minor and decreasing importance. We are concerned almost entirely with the *costs* of translating raw materials in the place of production into finished products in the place of consumption. The optimum location is that in which the total of these costs is less than the selling price obtainable by the maximum amount.

ANALYZING COSTS OF PRODUCTION.—It is convenient to divide these costs loosely into direct, or operating, costs, and indirect, or overhead, costs. The direct costs include those connected with raw materials, marketing, power and fuel, labor, water supply, and waste disposal. The indirect costs include those of land; fixed equipment (including buildings); machinery, tools and auxiliary equipment; taxes; maintenance of heat, light, and moisture; administration; advertising; liquid or free capital; and others.

Each of these factors has been studied in detail to determine to what extent they may vary with different locations, and how important such variations may be. The conclusions can be given only in summarized form.

The direct or operating costs are of course the most important in practically all kinds of manufacturing (in contrast, it might be noted, with agriculture or railroad transportation). Consequently plant loca-

tion should depend chiefly on the factors of direct costs, and if changing conditions in these factors make the location disadvantageous, the inertia of fixed investment in land, buildings, and others is seldom sufficient to prevent, for more than a short time, the shift of the industry to some other location.

Many cost factors are of very minor or negligible significance in the location of modern industries, either because they constitute such a small part of the total costs, or because they are usually but slightly affected by differences in location, or for both reasons. These are the factors of administration; advertising; capital; fixed equipment, including buildings; tools and auxiliary equipment; and maintenance of heat and light.

The factors of taxes, machinery, and the maintenance of moisture conditions are normally as of little significance to plant location as those of the first group, but for certain industries, or in special locations, may be of very considerable importance.

Factors that show far greater variations in local conditions within limited districts than in general conditions in large regions may be of great significance in determining local sites for plants, but have little effect on the general location. The factor of land is always important in this connection and, for industries requiring them, water supply and waste disposal may be most important.

Finally there are four major factors of direct cost which usually vary most with location and are therefore most important in determining plant location, namely the factors of raw material, power and fuel, marketing, and labor.

Geographic Conditions Affecting Costs.—It will be observed that, with the partial exception of the labor factor, all these factors, major and minor, vary from one location to another, largely because of differences in the locus with relation to other areas or places. Special exceptions can always be noted; climate in the maintenance of heat and light in all industries, and moisture in the textile industries; relief, surface waters, soil, and climate in the cost of land improvements, buildings, waterways, etc.; surface waters and relief in the cost of water power, water supply and waste disposal; but for the most part these are of minor importance, either because the factors are themselves small in amount, or because suitable conditions are generally available.

Ultimately, in the great majority of cases the problem of plant location may be reduced to differences in labor costs and locus in reference to three sets of places or areas—those of raw material production, those of power and fuel resources, and those of consuming markets.

Granted that those are the four principal factors concerned, we need some method of measuring their relative importance in different industries,—other than the inductive method of studying the present distribution of plants of particular industries and correlating the relations found thereby. The method used in the study of the iron and steel industry, which was based on the amount and character of the materials involved—raw materials, fuel, and finished goods, is generally applicable in the case of three of the four major factors. In all industries, differences resulting from different locations in the cost of raw materials at the plant and the cost of shipping the finished products to the markets, are clearly dependent on the amounts of the materials involved and the costs of transporting them. Power and fuel, whether used for power, for heating, or for chemical reduction, may be derived in practically all industries, from coal, and hence the requirements are always measurable in terms of tons of coal.

The relative importance of these three factors in influencing factory location is to be measured in terms of four variables: (1) the quantities of the commodities handled, (2) their perishability, (3) the unit costs of transporting them and (4) the extent of concentration of the producing or consuming areas. A few examples will have to suffice to illustrate these.

Some Typical Industries.—Industries which convert raw materials into a much smaller quantity of finished products, the residue being essentially waste or of very low value, will tend to be located close to or within the areas producing the raw materials rather than the market areas, (e.g., saw-milling, ore-reduction, and sugar-milling).

In certain industries such as nitrogen-fixation, or the manufacture of aluminum, the amount of power used is so great that the power factor, as measured in tons of coal, overshadows all other factors; since the cheapest sources of power are large water power resources, these industries tend to concentrate at the large water power sites. (e.g., Niagara Falls; Shawinigan Falls, Quebec; Muscle Shoals.)

A slightly more complex situation is found in the wood-pulp industry: one hundred tons of pulpwood produce less than thirty tons of pulp, but the power required is the equivalent of about 120 tons of coal, hence the location of so many pulp mills at convenient power sites close to the forest area.

If either the raw materials or the finished products are highly perishable, locus with reference to the areas producing or consuming the perishable commodities is clearly the major factor. Consequently we find dairy factories, and canneries of vegetables, fruits, and fish within or close to the region of raw material production; while bakeries,

ice cream factories, and newsprinting establishments are found in the centers of consumption. Where both groups of commodities are somewhat perishable, as in the meat packing industry, their relative importance is indicated by the special handling costs—refrigeration, depreciation, etc.

Importance of Transportation Costs.—The unit transportation costs are usually higher on finished goods than on raw materials, so that when the manufacturing process involves little or no loss in weight, and the raw material is non-perishable, locus with reference to markets is more important than that with reference to raw materials. It might be noted that this conclusion conflicts with the serious error not infrequently heard in the argument that the finished goods, being more valuable, are "better able to bear the cost of transportation." Transportation costs of coal are always less than those on finished products and usually less than those on raw materials; consequently that factor is less important, in proportion to amount handled, than the others.

Where either the sources of raw materials or the market for an industry is concentrated in a small district, the influence of that factor is not only more readily determinable but is greatly enhanced. As this feature is usually least characteristic of the markets, the importance of that factor is in many cases much less than would otherwise be expected. On the other hand, it is just this feature which gives such importance to the presence of a large local market in the immediate neighborhood of a plant, even though that constitutes less than half of the total market for its products. (e.g., the clothing industries in large cities.)

A contrasted situation is found in the manufacture of cotton. Since nearly all American cotton mills use a variety of raw cottons obtained from different parts of the South, a cotton mill at Atlanta may have little or no advantage of locus with reference to raw cotton over a mill at New Bedford, because of coastwise transportation from southern ports.

The high degree of concentration of the sources of power and fuel, whether from water power or coal, is nearly always to be counted on as increasing the relative importance of that factor.

In view of the dependence on transportation elements of these three of the four major factors affecting location, the intimate and all-important relation of transportation to the location of industries is clear. This is the three-fold advantage of seaboard districts as compared with interior districts in the development of a large number of industries; likewise it helps to explain the concentration in interior regions of

manufacturing around the larger rail centers. In addition to the primary advantages of routes to and from many areas of production and consumption, such centers have the resultant advantages both of special transportation privileges and rates, and of more abundant and cheaper labor, capital, machinery and other materials. The special advantage of location at points of necessary transshipment—e.g., lake ports and ocean ports—which permits the saving of one handling, is obvious.

LABOR AS A FACTOR IN LOCATION.—Evaluating the influence of the labor factor is more difficult, but not impracticable. From the point of view of economic geography, labor may conveniently be divided into three classes: unskilled laborers, skilled workers (including in both these classes only adult male workers), and the so-called "parasitic" labor, consisting of the dependents, women and children, of the adult male workers in other industries and including both skilled and unskilled, both factory workers and "home workers."[4] The following generalizations are significant to the geographer: unskilled labor is found in naturally increasing numbers in all population centers, may readily be drawn from other industries—including agriculture—and is readily transferred from other regions or countries; workers skilled in a particular industry are to be found in large numbers only in districts where that industry or allied industries are well established, is developed in new areas only at great expense, and is extremely difficult to transfer from other districts; "parasitic" labor is found chiefly in large cities and in permanent mining communities, and is extremely difficult, if not impossible, to move more than commuting distance.

Aside from the cost of transferring labor to new places, labor costs depend on a great variety of factors including: labor unions and labor laws—usually more important in older areas and for skilled workers; the cost of living, which gives a permanent advantage to location near surplus agricultural areas; and the efficiency of the labor, which is affected by its community training, racial characteristics, labor unionism, living conditions, and climate. (The determination of importance of this last factor, climate, is too difficult a problem for discussion here.)

Whatever the elements involved in the labor factor, their total effect may be measured in terms of cost of each class of labor, per ton of raw material, fuel, or finished product. In case this cost for the skilled labor class or the parasitic class is very high, the labor factor may be the dominant factor in plant location—as it clearly is in the manufac-

[4] A special class, seasonal labor, is of such minor importance in most types of manufacturing as to be disregarded here.

ture of jewelry, silverware, and other articles of exceptional value. The presence of labor skilled in such industries is the most important element in the concept of "advantage of an early start."

This means of measuring the importance of the labor factor may be illustrated by two contrasting examples, the textile industries, and the flour-milling industry. Using census figures for the United States in 1919 we find that in the textile industries the cost of labor, consisting largely of the immobile classes, per ton of raw material was $270 in the cotton industry, $688 in the woolen industry, and $4,500 in the silk industry. The same costs per ton of coal that would be required to generate all the power used were roughly $48, $47.50 and $89 respectively. An increase of as much as ten per cent in these labor costs which a new location might necessitate, would off-set very great advantages in freight rates due to closer proximity to raw materials, markets or power. On the other hand, in the flour-milling industry a total labor cost of $2.10 per ton of grain, on which freight rates vary by more than a dollar for a difference of only a hundred miles, indicates that the labor factor is negligible in determining the location of the industry.

When the labor cost is high, but consists chiefly of wages for unskilled male laborers, the mobility of this type of labor will prevent this factor from being of major importance, excepting in discouraging location in areas of notably high cost of living.

Conclusion.—This paper has attempted to outline a method by which we may study the geography of any manufacturing industry to determine the importance of the different factors affecting the distribution of its plants. In general it is found that locus,—i.e., relative location with reference to specific areas—is the all important element; that locus with reference to areas of raw materials, power or fuel, and markets, together with the labor factor are the four major factors influencing factory location; other minor factors have been touched on; the important relation of transportation to factory location has been analyzed, so that it can be properly evaluated in any particular case; a concrete means of measuring the quantitative importance of each factor has been described and illustrated. This method should provide not merely a basis for correlating present and past situations with natural and economic conditions, but also a basis for making predictions or recommendations for the future.

Certain important questions naturally arise however in regard to the factor discussed as all-important—i.e., locus or relative location. Geographers are by no means in agreement with regard to this factor. Its name, its exact definition or even general meaning, the manner of

describing or measuring it, and its position among the other factors, natural and social, with which geographers deal—on all these points few geographers would agree, though all must recognize the great importance of the factor, not merely in manufacturing, but in other activities. The analytical study of the cultural landscape in a market gardening belt, or a dairy district, or a wheat farm is essentially incomplete if this factor be left out. The same is obviously true of every commercial enterprise in agriculture, mining or lumbering.

Considerable thought and study have been devoted to this question, the results of which will require a separate paper, to present a definite concept of this important factor on which agreement may be possible, and which will permit of definite classification and more or less definite measurement.